ORDNANCE

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B-58 Supersonic Bomber

NOVEMBER-DECEMBER 1958

SPECIAL PICTORIAL REPORT ON THE LACROSSE MISSILE . . . . PAGE 106

U. S. Army photo

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Thirty-nine Years of Leadership in American Armament

VOL. XLIII | NOVEMBER-DECEMBER 1958 | NO. 231

The Cover.—*The Convair delta-winged B-58 Hustler is the Air Force's first supersonic bomber. It has a wing span of about 55 feet and is approximately 95 feet long and 30 feet high. Powered by 4 General Electric J-79 turbojets, it carries a crew of 3 (photo by Joseph Goodyear).*

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Advertising Representative: Thomas O. Woolf & Son, Inc., 70 E. Forty-fifth Street, New York 17, N. Y.; 266 South Alexandria Avenue, Los Angeles 4, Calif.

ORDNANCE is published bimonthly by the American Ordnance Association, Mills Building, Washington 6, D. C. Second-class mail privileges authorized at Washington, D. C.

Subscription rate: Continental United States and possessions, $4.50 annually in advance; foreign, $6.00.

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Six weeks' notice before next publication date required for change of address.

FIREPOWER, formerly published separately by the American Ordnance Association, is combined with ORDNANCE magazine.

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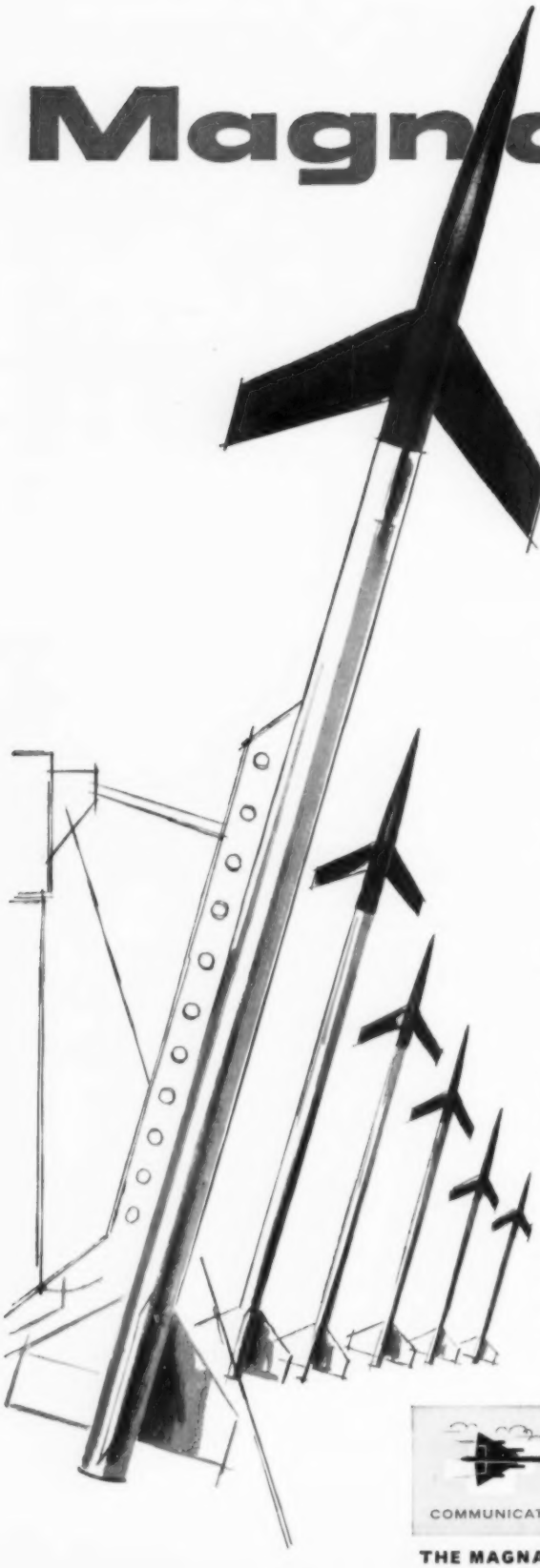

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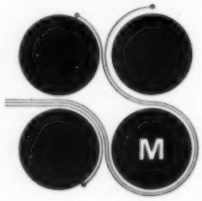

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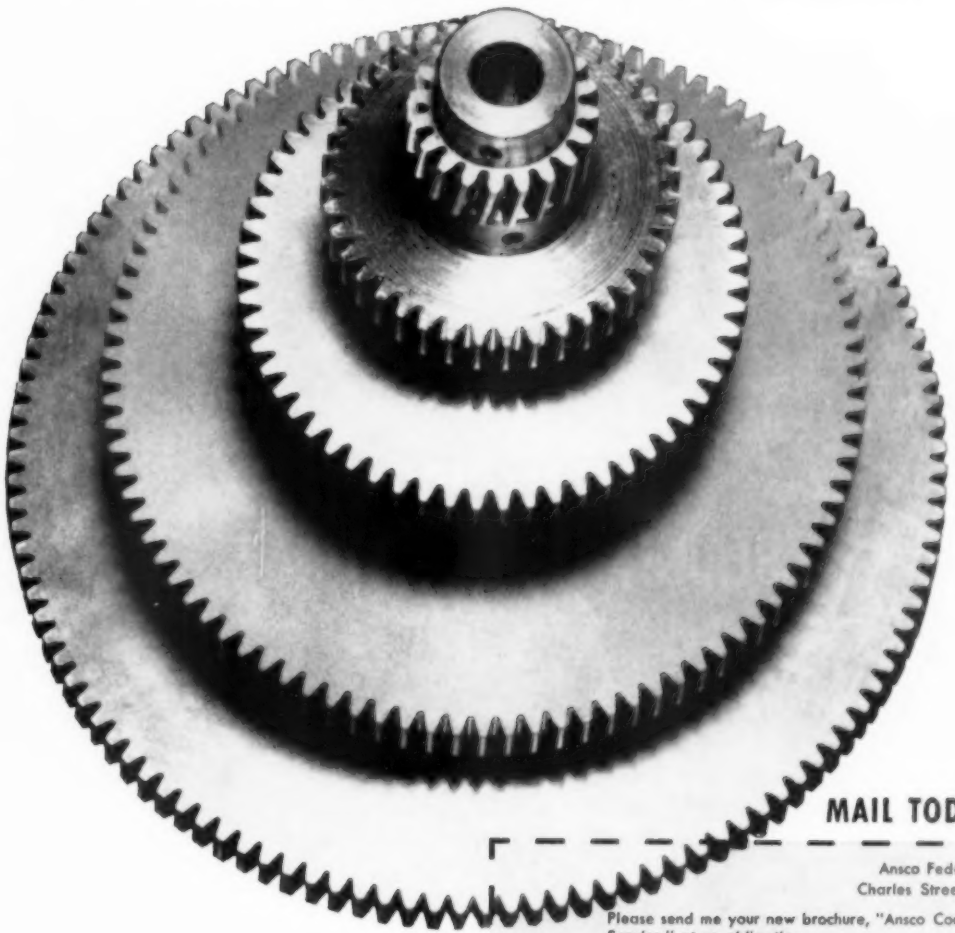

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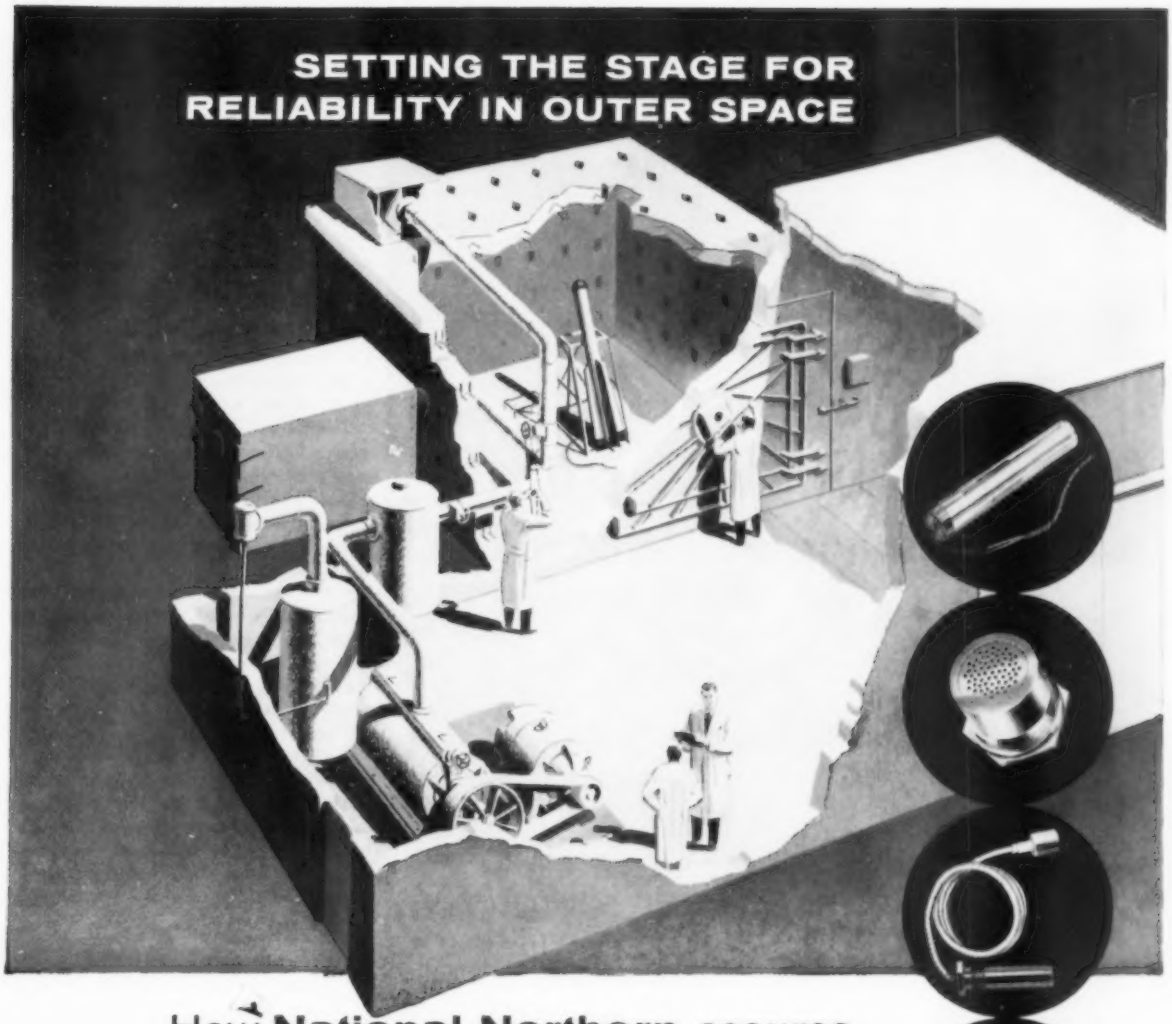

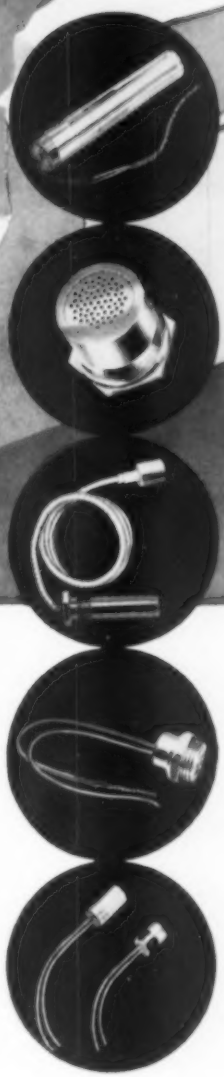

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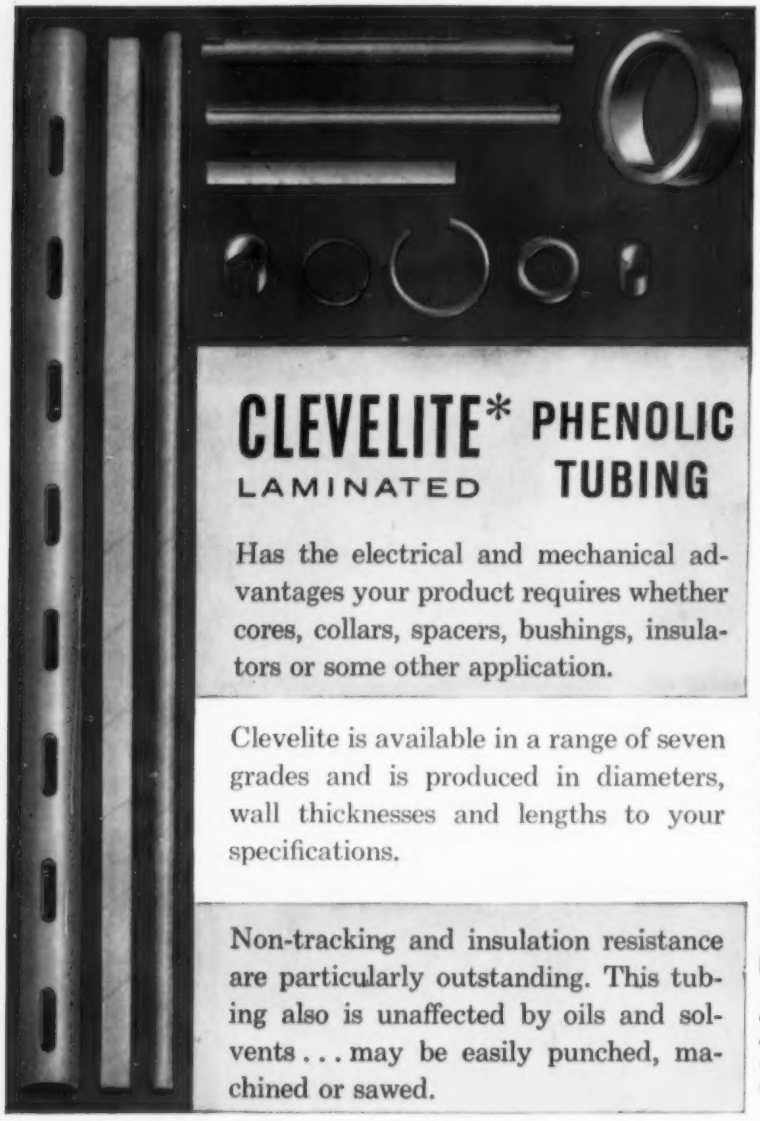

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ATOMIC ENERGY

Heavy Water Leased

The Atomic Energy Commission has established a policy to lease or sell heavy water for use in domestic or foreign research, medical, or testing reactors. Heretofore, AEC transactions in heavy water were primarily on a sale basis.

The domestic or foreign requestor will now have a choice of leasing the material at 4 per cent per annum of the sales price or purchasing heavy water at the established price of $28 a pound. The heavy water will be leased in quantities of one short ton or more for the initial inventory requirement of the reactor.

For domestic research or medical reactors the term of the lease will be for the period for which the reactor is licensed; for foreign research, medical, or testing reactors, it will be for the estimated useful life of the reactor. Heavy water for domestic testing reactors will be leased for five years, subject to renewal for the duration of the period for which special nuclear material is also leased.

Radioisotope Course

The Atomic Energy Commission recently announced plans for a new series of radioisotope technique courses at Oak Ridge, Tenn., especially designed for representatives of industry.

The 6-week courses will be presented by the special training division of the Oak Ridge Institute of Nuclear Studies (ORINS) as part of the Commission's development program to expand the applications of radioisotopes.

Initially, two courses have been scheduled—the first to begin February 9, and the second to start April 6, 1959.

It has been estimated that American business now is saving millions of dollars a year by using radioisotopes, although less than one per cent of the manufacturing and mining concerns in the Nation are using these materials. The Commission expects a broadening use of radioisotopes will bring about substantial increases in these industrial benefits in the next few years.

The new Oak Ridge course will consist of lectures, seminars, demonstrations, and laboratory sessions. The work will emphasize practical plant applications of radioisotopes, including standard tech-

niques of wear measurement, thickness measurements, and radiography, in addition to other techniques applicable to industrial operations.

Plutonium Reactor Fuel

A reactor of the Atomic Energy Commission is operating for the first time at substantial power with plutonium 239 as the fuel. The materials-testing reactor (MTR) at the Commission's National Reactor Testing Station in Idaho, normally fueled with uranium 235, was brought to criticality with plutonium as its fuel and has a design power level of 30,000 kilowatts.

This experiment is expected to advance the technology of plutonium fuel-element handling and fabrication, provide operational experience with a plutonium-fueled reactor, and provide reactor physics data.

The MTR, which began operating in 1952, provides facilities for determining the effect of intense reactor radiations on materials considered for use in fuel elements, heat-transfer systems, structures and shields of new reactors. It also is used to test new and improved reactor fuel cores.

Only minor design changes were required for the use of plutonium rather than uranium 235 as the fuel. The amount of plutonium required for an MTR fuel loading is less than for uranium 235 because of differences in their nuclear properties.

As an additional experiment with fuel loadings of different fissionable materials, the MTR, after a test period of power operation with the plutonium loading, will be loaded with fuel elements fabricated with uranium 233, the synthetic isotope of uranium derived from thorium. In a previous experiment, the MTR was operated successfully with a core loading of fuel elements containing uranium enriched to 20 per cent in U-235 rather than the usual high enrichment of 93 per cent.

Nuclear Technology

Details of three advanced-study courses in nuclear technology which the United States is establishing in existing U. S. Atomic Energy Commission facilities for the students of friendly foreign nations recently was presented to delegates at the Second International Conference on the Peaceful Uses of Atomic Energy in Geneva.

The courses are: Reactor Hazards Evaluation, Reactor Supervision, and Radiochemical and Counting Procedures. The first two courses will be conducted at the Commission's Oak Ridge National Laboratory at Oak Ridge, Tenn., beginning February 2, 1959. Radiochemical and Counting Procedures will be given at the New York Health and Saftey Laboratory

(Continued on p. 354)

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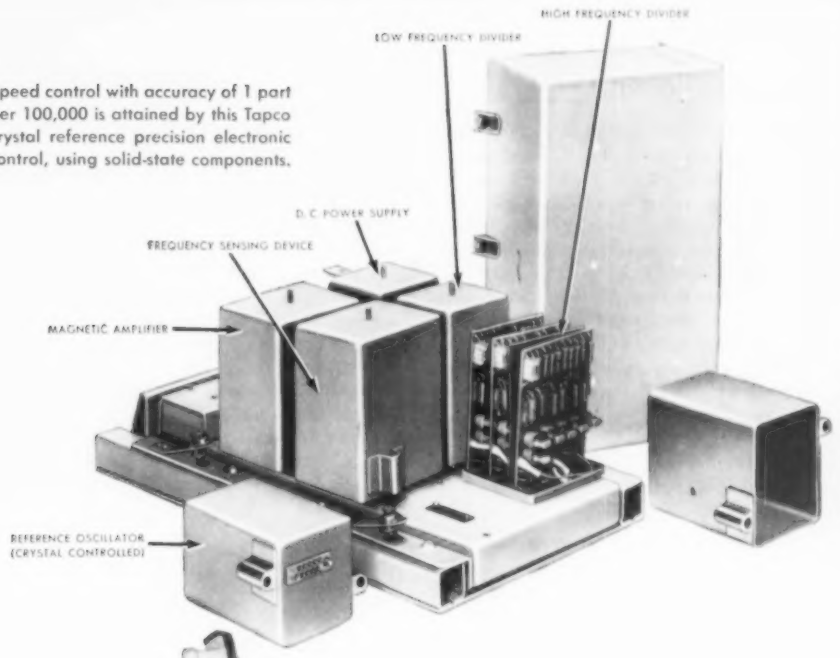

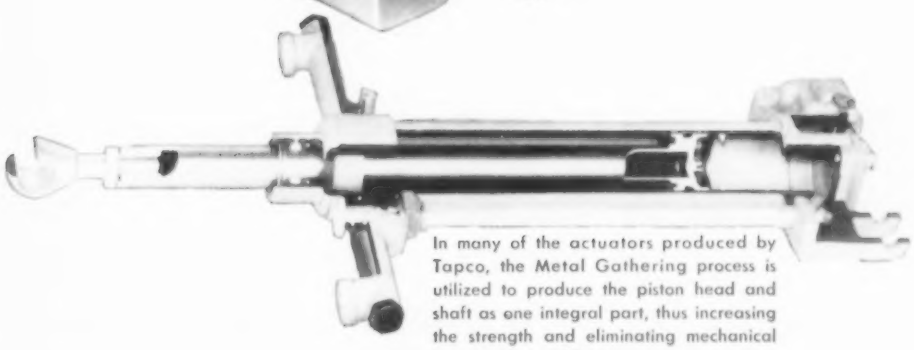

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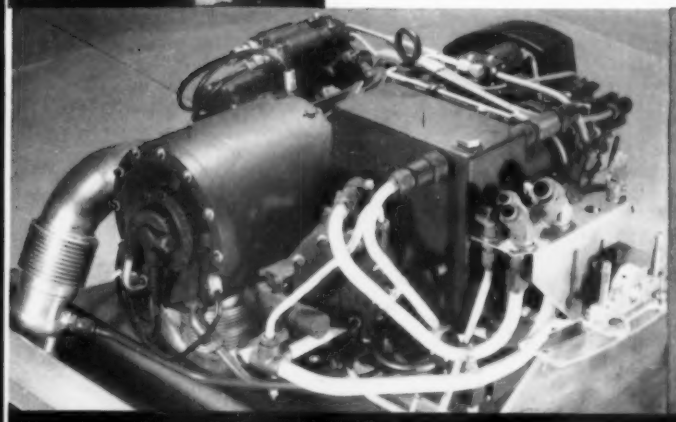

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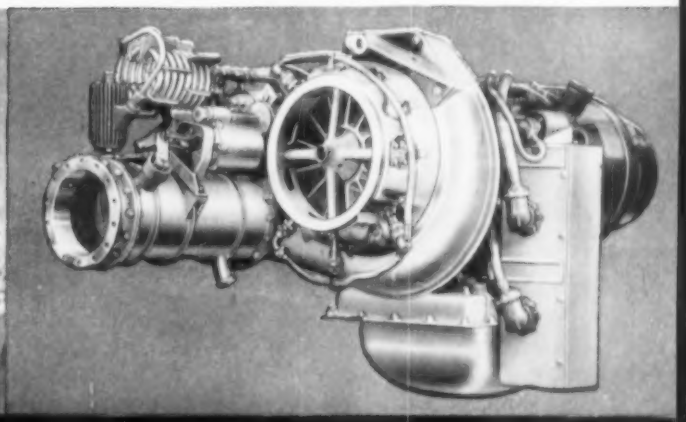

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Atomic Energy (Contd.)

of the Commission in New York City.

The sessions at Oak Ridge National Laboratory will be given once each year. Hazards-evaluation training will be of twelve months' duration while reactor-supervision studies will continue for nine months, with accommodations for about ten students in each class. Radiochemical and Counting Procedures will require six weeks of study, will be given four times each year, and will accomodate six students in each class.

Low Power Reactor

The Argonne Low Power Reactor (ALPR), the prototype of a nuclear reactor designed to produce electric power and space heat at remote military stations, achieved criticality at the Atomic Energy Commission's National Reactor Testing Station, Idaho Falls, Idaho. It has full-power level of 3,000 thermal kilowatts.

The ALPR-type plant is a "package" reactor designed to be erected on any type of terrain and with a minimum of on-site construction. It contains a direct-cycle, natural-circulation, boiling-water reactor fueled with enriched uranium and moderated with light water. The heat from the reactor can be used to generate about 260 kilowatts of electricity and 400 kilowatts of space heat. The electricity of ALPR-type plants at military sites would be used to supply power for radar equipment and space heat for offices, barracks, and other buildings.

The reactor is designed to operate for three years with each fuel loading. This prolonged operating period simplifies the task of operating isolated plants by eliminating the need to deliver large quantities of conventional fuel and maintain facilities for this fuel.

ALPR components can be easily transported in Air Force cargo planes. No reactor component weighs more than 20,000 pounds or has dimensions greater than 20 by 9 by 7 feet. The facility is designed for simple and safe operation and maintenance, with a minimum amount of supervision.

Research Contracts

Award of seventy-two unclassified physical research contracts totaling $3,052,513 to colleges, universities, and private research institutions was announced recently by the Atomic Energy Commission. Eleven of the contracts are new, and sixty-one are renewals of contracts already in force.

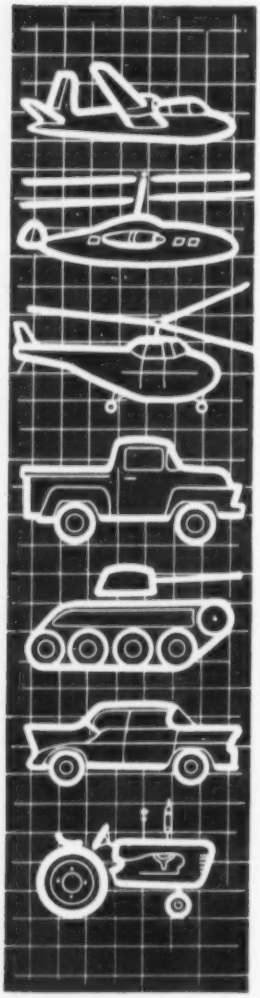
The award of these contracts is part of the Commission's continuing policy to assist and encourage nuclear research in educational institutions and private laboratories in the United States. The Commission usually shares the cost of the research with the institutions—the private organizations contributing the services and funds they ordinarily would put into research and the Commission providing funds to expand and accelerate the work.

Notre Dame University's $354,314 and the University of Minnesota's $286,741 were the largest contracts in this series of awards. Notre Dame's funds will be used for studies in radiation chemistry. The University of Minnesota's contract is for physics research which will be conducted in its 68 million electron volt linear accelerator.

Volumes Presented

The United States recently presented to United Nations officials in Geneva, Switzerland, sets of thirteen volumes setting forth the latest United States advances in Peaceful Uses of the Atom. The U. S. also will present complete sets of the volumes to the principal representatives of each country participating in the Atoms-for-Peace Conference.

Much hitherto unavailable or widely scattered information has been included in these volumes, which were prepared by leading U. S. scientists and engineers. The books, describing the theory of chain-reaction and various types of chemical and metallurgical techniques, demonstrate U. S. progress in these vital areas and the willingness of this country to share its information with the rest of the world.



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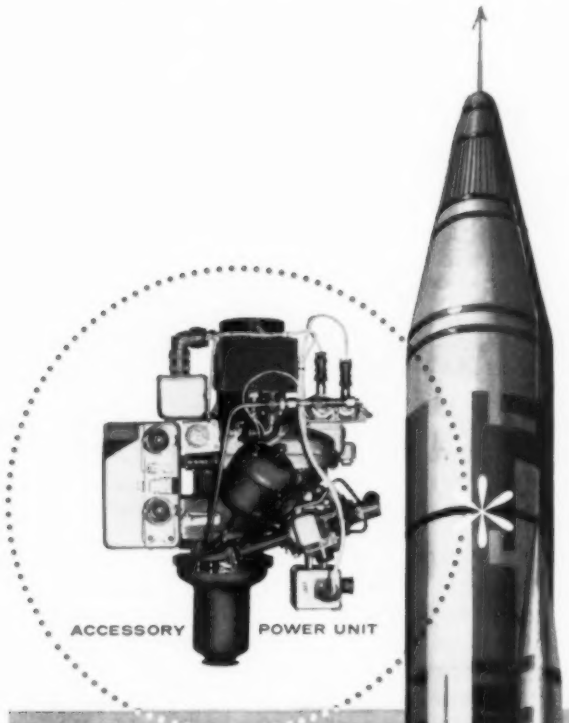
ON THE PAD



3 vital functions

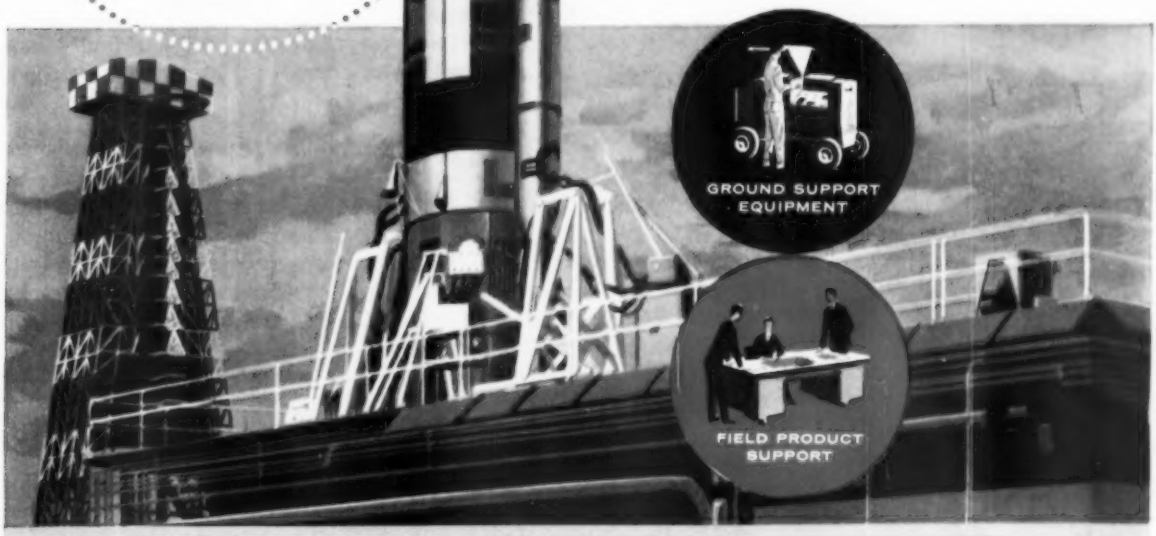
The ATLAS count-down ends—Sundstrand Turbo precision products go into action.

INSIDE THE MISSILE—the hot-gas accessory power unit, built by Sundstrand Turbo, provides hydraulic and electrical power.

ON THE GROUND—Sundstrand Turbo provides integrated ground support equipment, designed and built for both R&D and operational phases.

IN PRODUCT SUPPORT—Sundstrand Turbo provides vital logistics support, field engineering, technical manuals, and training for military and contractor personnel.

Sundstrand Turbo experience in creating secondary power systems using bi-propellants, monopropellants, and solid propellants—combined with research in nuclear, solar, and atomic power systems—has made the name Sundstrand Turbo synonymous with Secondary Power. *Our engineering representative will be pleased to discuss your requirements.*



SUNDSTRAND TURBO

A Division of SUNDSTRAND MACHINE TOOL CO

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Temco | AIRCRAFT DALLAS

Now on Duty with the Navy . . Temco's TT-1 Primary Jet Trainer

Now on duty with the Navy, Temco's TT-1 Pinto is an advance-guard aircraft . . first to introduce the concept of an all-jet syllabus for aviation training. And already, while still under evaluation, the Pinto is *growing* . . stepping up greatly in power, agility and safety.

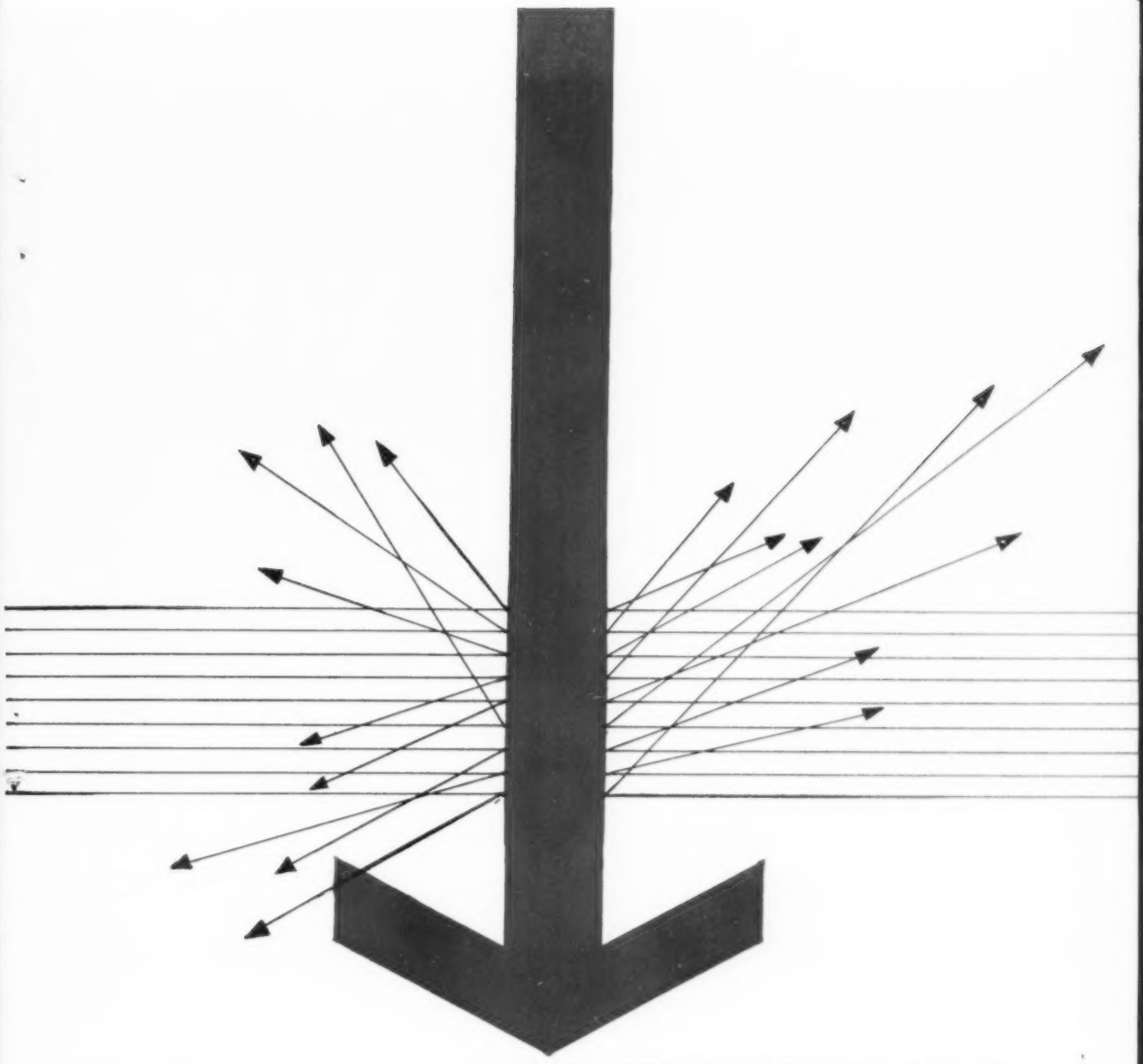
Designed from the very beginning for *growth through simple modification,* the production Pinto will be equipped with a Continental J69-T-25 engine in place of its J69-T-2. This engine changeover will be accomplished without noticeable change in outward appearance, without significant internal changes. Further modifications will extend the Pinto's ability to carry more equipment . . let it grow with the man . . make it capable of performing almost the entire primary/basic syllabus at considerably less than half the cost of any other jet trainer available or under development.

This sleek, speedy jet trainer was designed, developed and produced entirely by Temco. And while it is a prime example of the unusual talents and capabilities Temco possesses, it is just one phase of Temco's widely diversified work. Other phases are research and development in the field of advanced weapon systems . . new developments and fabrication techniques in stainless steel, titanium and other high temperature materials. All part of Temco's continued pioneering of the "total package" concept of design, tooling and production of aircraft and missiles . . of its complete weapons systems management capabilities.

Tomorrow's Need is Today's Challenge at..

TEMCO

AIRCRAFT CORPORATION • DALLAS, TEXAS



A MANAGEMENT GEARED FOR ACTION

Keeping pace with the demands of this high-speed era are the sweeping managerial advances within the Military Products Division of IBM. The result is a dynamic organization geared for action and organized for decision. The project officer of the military will now find his opposite number at IBM—equally dedicated to the accelerated development of the versatile equipment so vital to national security. These men are entrusted with complete operational responsibility for a project with full authority to cut across functional lines whenever it is necessary to expedite the results demanded by the special needs of the services. IBM has always responded at once to defense requirements. These most recent actions offer more evidence of the eminent qualifications of the IBM Military Products Division for serving the data processing and computer requirements of the military.

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Complete facilities for: Research • Development • Reliability Engineering • Manufacturing • Product Support

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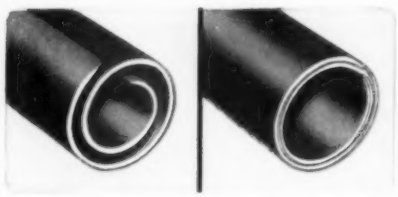
. . . and we do it with Bundyweld, the stronger, safer steel tubing that's made for easy bending

SKILLED Bundy® technicians turn out many a strange shape—each to its exact tolerances. At Bundy, you get precision *in mass-fabrication.* Jigs, fixtures—even machines—are designed by Bundy specifically to cut customers' unit costs.

You get Bundyweld® Tubing, too. An exclusive process (right) gives it unique physical properties. So Bundyweld—master of volatile refrigerants and high-pressure brake fluids—has become the safety standard of two major industries.

Bundy engineers will design your tubing part, or work with you on its development. When we fabricate your parts, you can count on careful packaging, on-time delivery. Bring *your* tubing problem to Bundy. Contact us today!



Bundyweld is the only tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

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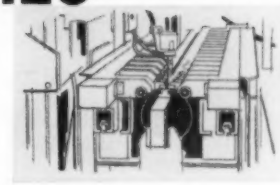
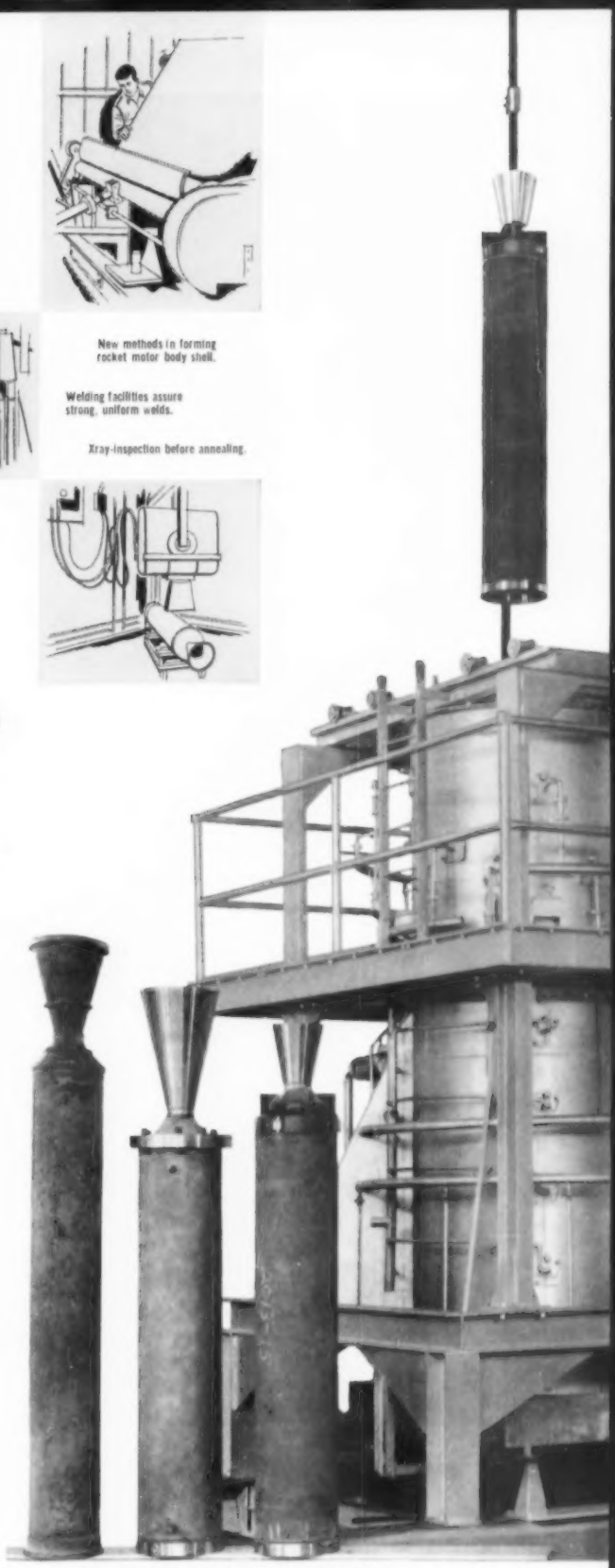


New methods in forming rocket motor body shell.

Welding facilities assure strong, uniform welds.

X-ray inspection before annealing.



National Electric's Contribution to The Rocket and Missile Program

ENGINEERING... A staff of engineering specialists with extensive backgrounds in physics, mathematics, stress analysis, metallurgy, thermodynamics, hydraulics, electronics and structural, mechanical and electrical design. Their efforts have resulted in mass production methods and techniques for the fabrication of rocket bodies and components faster, more economically and to closer tolerances than ever before achieved.

RESEARCH AND DEVELOPMENT... Since 1949 National Electric has been executing classified research and development contracts for the government. The results . . . an enviable record of pioneering achievements in the production of rockets and guided missiles . . . from the first Jato motor bodies to the famous Nike Hercules.

MASS PRODUCTION... Mass production has been achieved through continuing technical advancements and modern techniques. Currently extensive research and development projects are being conducted on several highly critical and important rocket motor bodies including mass production on the Nike Hercules.

Write for your free copy of our Rocket and Guided Missile booklet. Our experience can be an added asset to your experience.

A NATIONAL ELECTRIC FIRST

Advanced heat-treating methods developed by National Electric provide new and highly important breaks through in rocket and missile production.

NATIONAL ELECTRIC PRODUCTS — ROCKETS + MISSILES

ROCKET AND GUIDED MISSILE DIVISION

National Electric Products Corporation

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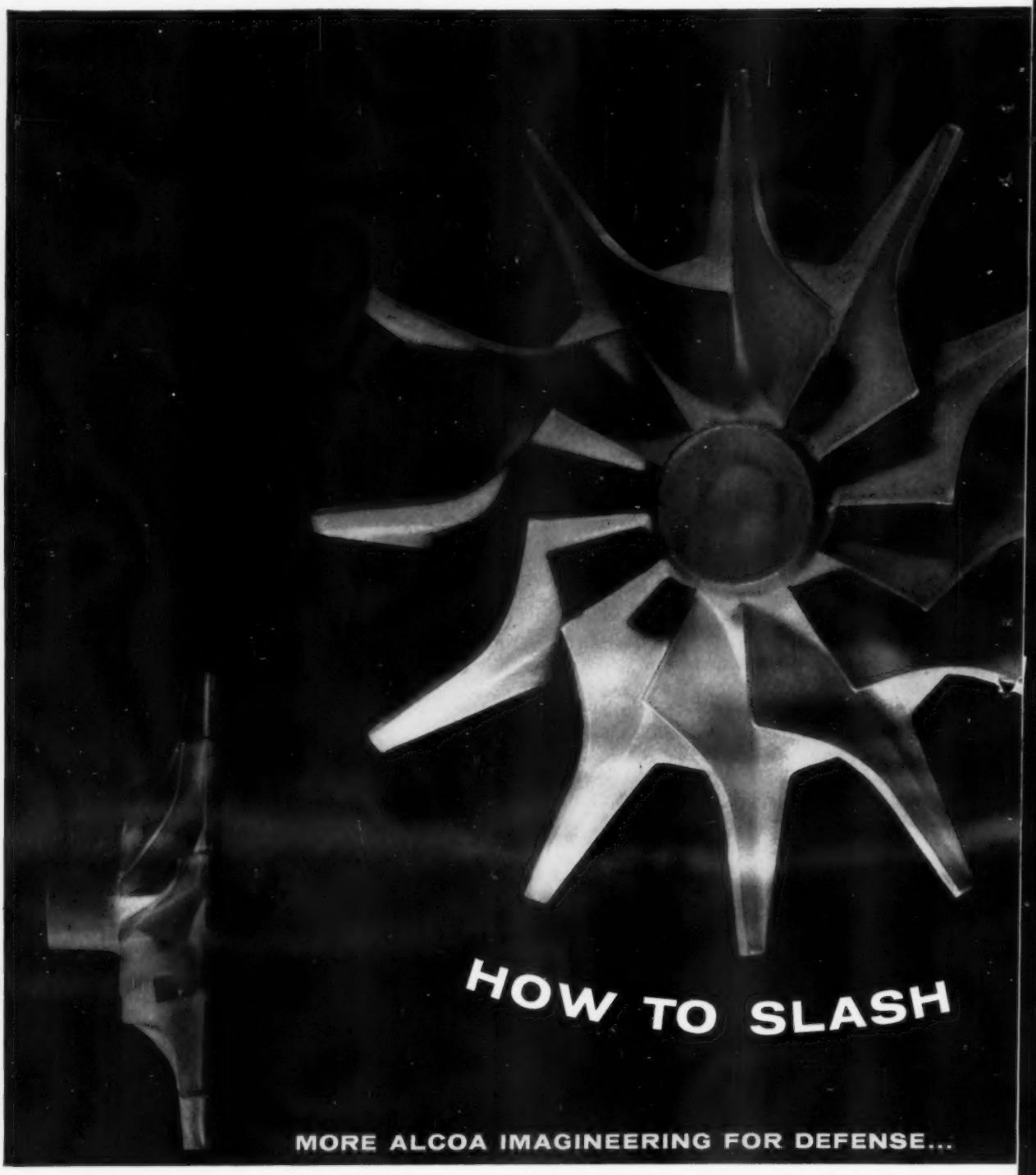
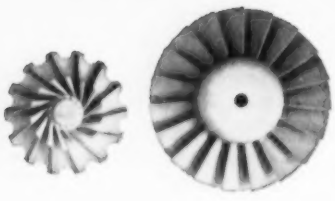
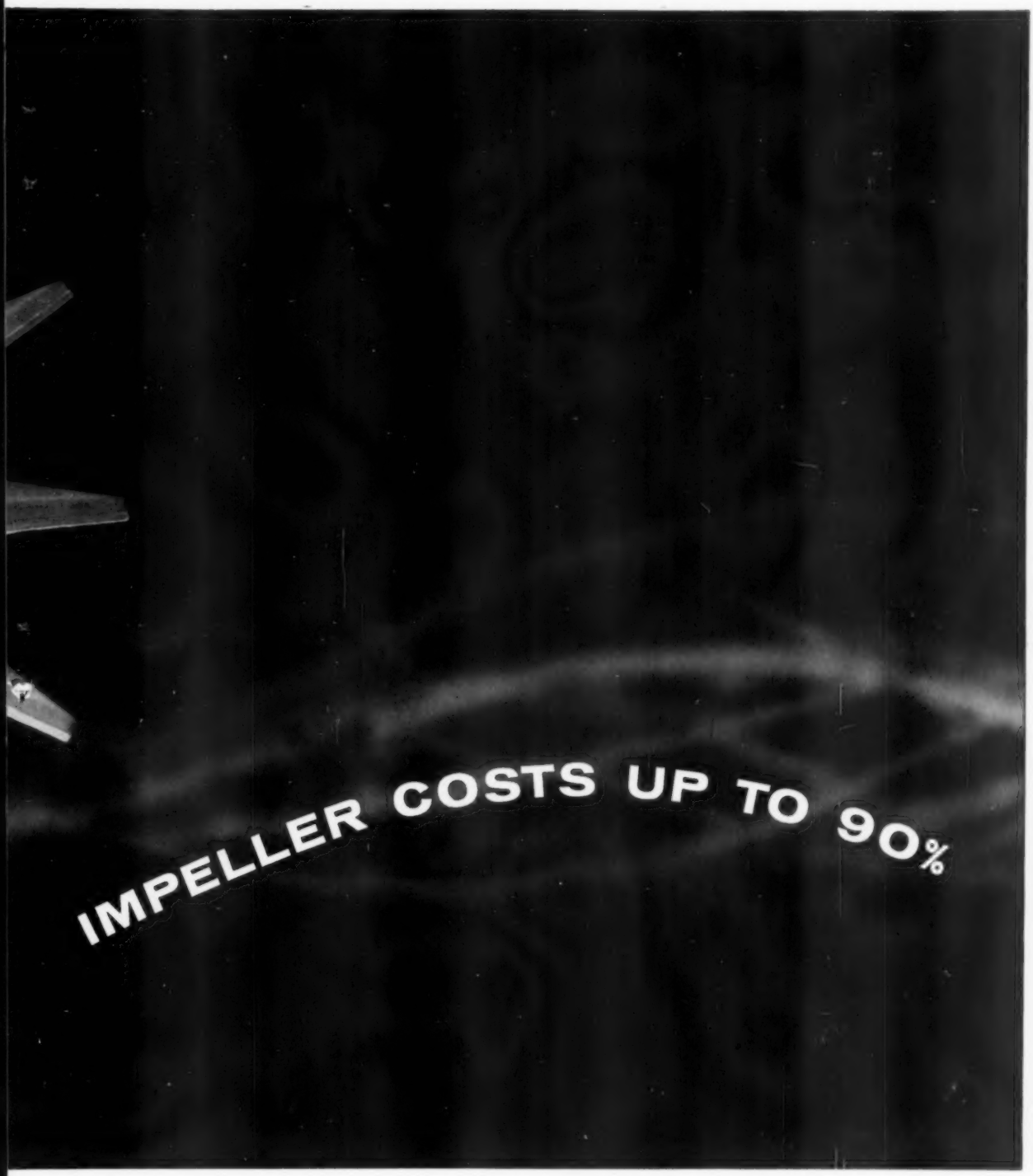




New Alcoa precision casting techniques are producing high-speed aluminum impellers at a fraction of their former cost. Eliminating many expensive machining operations, the Alcoa methods save as much as 90 per cent on many complicated aircraft, diesel truck and marine impellers.

Alcoa impeller castings meet every requirement for balance and surface finish. Cast with Alcoa premium-strength C355-T61 aluminum alloy and guaranteed in the casting,* they spin safely at tip speeds up to 2,500 fps (60,000 rpm for a 9½-in. dia. part). The castings are smooth, with a surface finish 125 microinch maximum guaranteed. The balanced,



curving blades, often tapering to a delicate 1/32-in. edge, fit an over-all ±.005-in. to .010-in. tolerance.

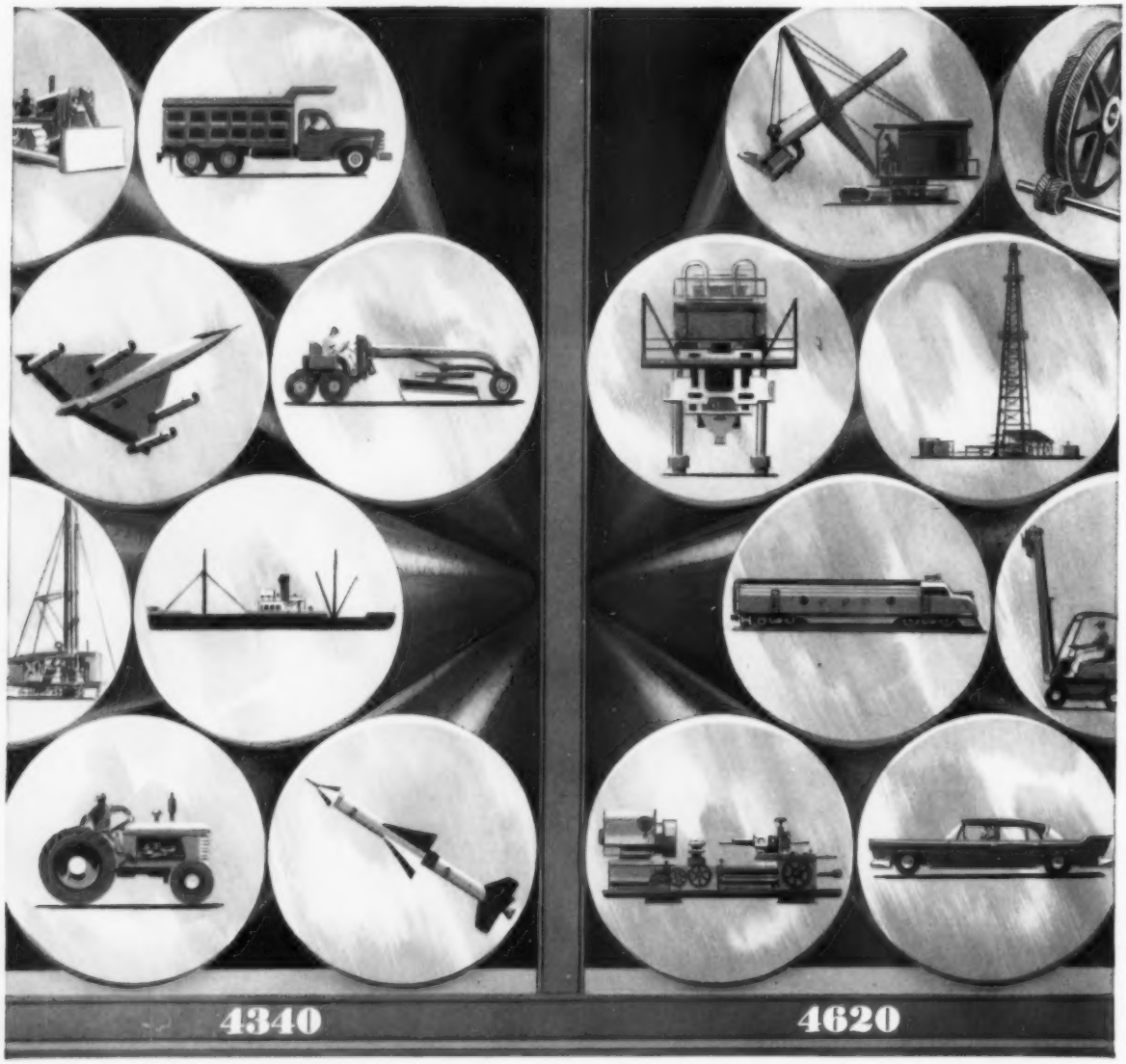
Further information on Alcoa's money-saving new impeller casting techniques is available to military designers, manufacturers and specifiers at local Alcoa sales offices or from Aluminum Company of America, 850-L Alcoa Building, Pittsburgh 19, Pa.

*Alcoa guarantees cast impellers of aluminum alloy which meet these specifications: tensile strength–44,000 psi, yield strength–33,000 psi, elongation–no more than 3 per cent.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA



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4620 is a carburizing type that has consistently proved itself the ideal steel for a wide variety of carburized parts. 4620 is easy to carburize and has a minimum tendency toward distortion in heat treatment.

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The Navy RAT anti-submarine weapon system aims and launches missiles that seek out and destroy enemy submarines. Librascope designed the fire control system for RAT and assisted the navy in ship-board system integration. The RAT fire control receives information from target locators and automatically aims and sets RAT for a "kill". Its computers determine the ideal position for a missile to intercept the target. When the missile is launched, it travels through the air and enters the water where it attacks the target for "kill".

...a new anti-submarine weapon...
the fire control was designed and developed
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The background of more than twenty years of design, development and manufacture of computers, controls and instrumentation are inherent values in all Librascope products. This experience and versatility in electronic, magnetic, mechanical and optical design concepts make for a new kind of reliability. Whether components or complete systems, Librascope can point to notable achievements. Let Librascope *solve* your computer problem. An inquiry on your letterhead will bring further information.

Librascope's use of the LGP-30 computer simplifies complex design and production problems, and assures computer-engineered quality in meeting design and delivery schedules.

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maximum mobility!

Multiple-wheeled rubber-tired vehicles, whether 6 x 6's or 8 x 8's, are built to provide maximum mobility under all conditions. Versatile and dependable . . . capable of fast highway speeds, as well as high maneuverability over rugged terrain . . . they offer the advantages of all-wheel traction, low floatation pressures, proven cargo stability, and greater load capacity in relation to vehicle weight.

Most of these vehicles can be made of standard driving components, and parts for these components are now available through the world-wide military supply system. They can be assembled in any combination to make driving units for four-, six-, or eight-wheel vehicles.

For nearly 50 years, Timken-Detroit® Axles and Transfer Cases have been a major component for military vehicles. Now, with the addition of Hydra-Drives® Torque Converters and Power Shift Transmissions, Rockwell-Standard can supply complete power transmission assemblies—everything between the engine and wheels.

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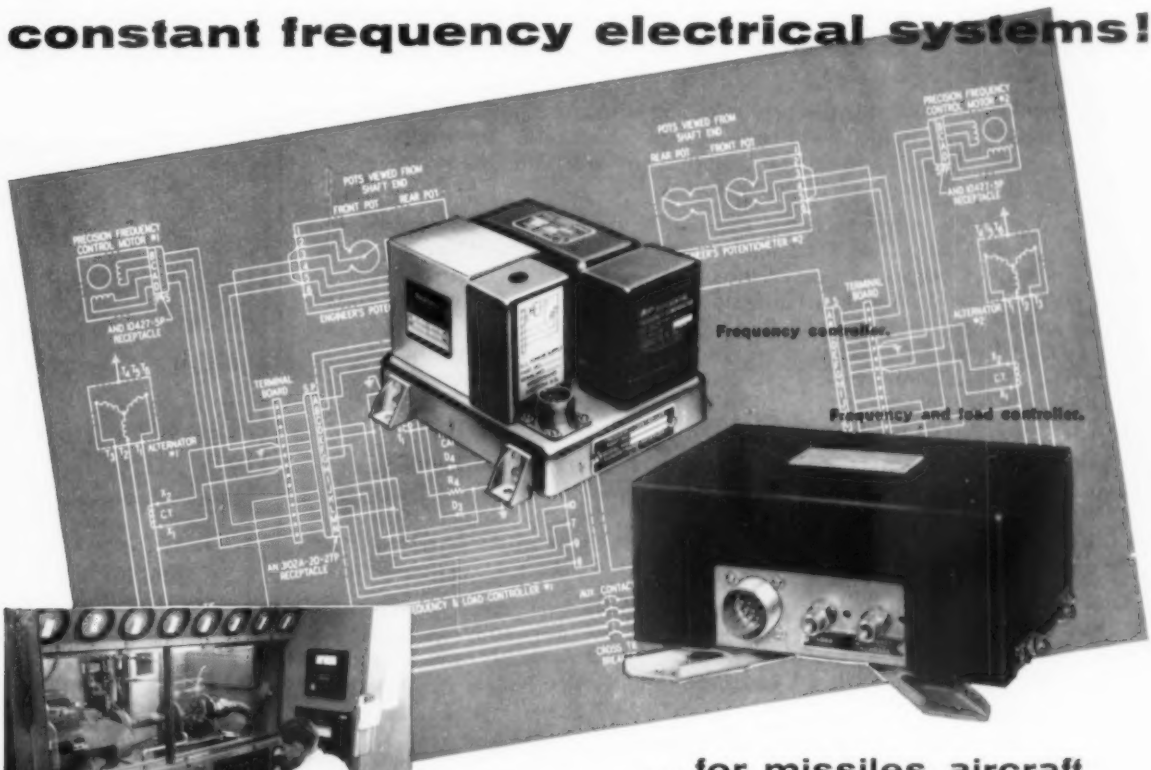
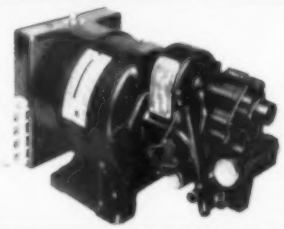
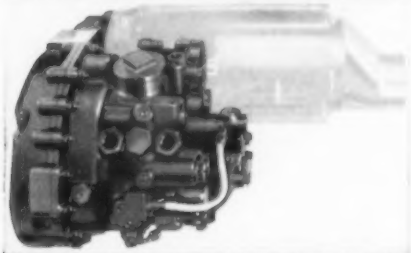
SUNDSTRAND . . . a primary source for constant frequency electrical systems!



Operator's console for one of the constant speed drive test stands at Sundstrand Aviation.



Sundstrand controlled-speed variable-displacement hydraulic motor with alternator—for use with Sundstrand hydraulic pump to provide controlled frequency electrical power.



Sundstrand constant speed drive for the Regulus II missile.

. . . for missiles, aircraft and ground support equipment

Evidence of Sundstrand Aviation capabilities for the development and production of constant frequency electrical systems for guided missiles, aircraft, and ground support equipment is indicated in the following experience record:

- First airborne constant speed drive system and controls for 400 a-c electrical systems (B-36 in 1946).
- Drives proved by more than 4,000,000 flight operating hours.
- Constant frequency electrical systems prime contractor for Regulus II, SAAB J-35, and the F-8U3.
- Subcontractor on systems and components for nearly all first-line U. S. military aircraft.
- Portable field test stands for testing of complete electrical power generating systems.
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A Down-To-Earth Look At Today's Missile Picture

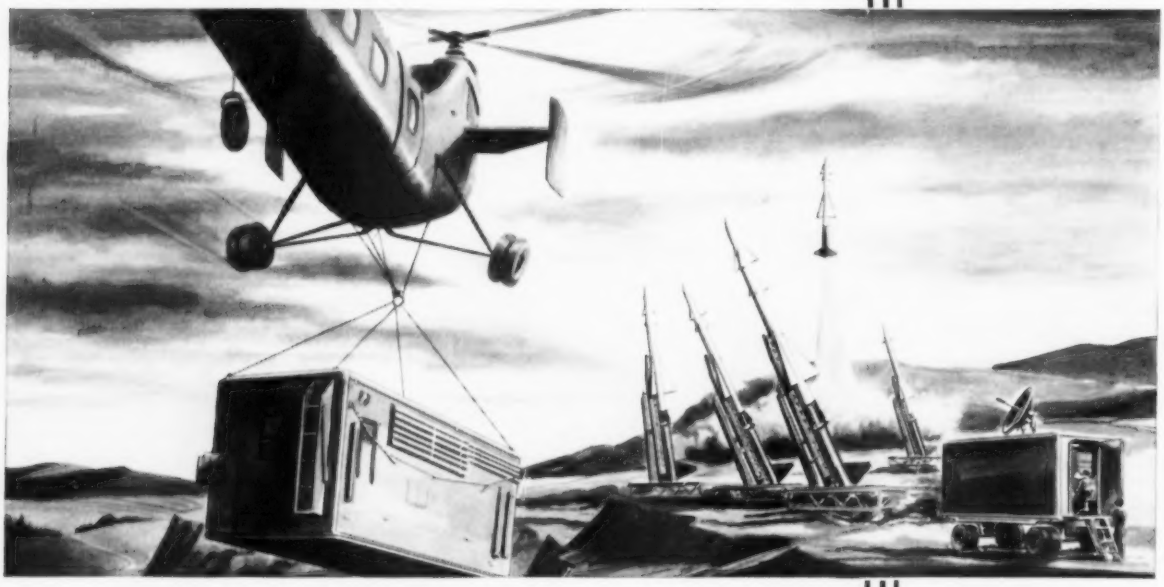
NOW that operational missiles are becoming a reality and production in quantity a fact, it has been necessary to look at the tremendous storage, transportation, and ground handling problems from a practical, dollar-conscious, down-to-earth point of view.

Each day more assignments for the development and manufacture of *practical, economical* handling units are being brought to Fruehauf, long known for its expert experience and education in commercial transportation areas. And Fruehauf has successfully responded in filling the need for the design and manufacture—at lowest possible cost—of dependable, versatile, multi-purpose ground handling units in quantity —on practically a commercial level. This is the business like approach to the missiles picture, but it must be made, and no one is better equipped and staffed than Fruehauf to do so.

Not only in relation to missiles but for *many* military ground-handling needs, Fruehauf research, engineering, and manufacturing knowledge is being utilized profitably by the services and other contractors. Here are a few of the widely varied projects with which Fruehauf has been associated in a development or manufacturing capacity:

- **Ground handling equipment for 17 missile types**
- **Missile launchers**
- **Guidance shelters for missiles**
- **Shelters for electronic and radar equipment**
- **Specialized tank-trailers for fuels**
- **Power haul vans**
- **Vans for testing equipment**
- **Standardized refrigerator vans and other mobile materials containers**
- **Formal detail specification drawings in quantity**
- **Rough terrain trailers**
- **A total of over 400 different types of military vehicles**

You can put confidence in Fruehauf's long experience and extensive facilities in meeting any ground handling problem concerning missiles, guidance shelters, weapons systems, or materials supply.



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DYNAPAC is typical of the manufacturing and test equipment used by Bourns to assure you that *all* Bourns products exceed the high reliability requirements of today's electronic systems. If you would like more technical information on DYNAPAC, or a copy of our Instrument Model Summary Brochure, write BOURNS LABORATORIES, INC., P.O. Box 2112G, Riverside, California • Or contact a Bourns Field Office: 21 Walt Whitman Road, Huntington Station, L.I., New York • 4515 Prentice St., Dallas 6, Texas • Exclusive manufacturers of TRIMPOT® and TRIMIT®, and Pioneers in Potentiometer Transducers for Position, Pressure and Acceleration.

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move it in . . . couple it . . . turn it on . . .

with a VICKERS "packaged" unit power is instantly available to operate your missile-support system

Fast and easy installation is an important advantage of these "packaged" hydraulic power and control systems by Vickers. It saves time at the missile site — keeps "on-the-spot" labor charges low. That's important! Yet this fast installation is only one of the benefits you get with these factory-built power packages.

Save Design Time — Since 1932 Vickers has custom designed hydraulic power packages. Thus, we know how to avoid "false starts" and can develop highly efficient units *in a hurry.*

Eliminate Mismatching — Each power package contains compatible, balanced components all produced by Vickers. There are no hybrids — there is no need for "force fits".

Save Space — Units are surprisingly compact, yet all components are easily accessible. Solid steel drilled manifolds reduce piping and space. Components, lines and connections are kept to an absolute minimum.

Simple Field Adjustment — The building-block concept is followed to give component interchangeability, servicing ease and quick location of any malfunction. All components are individually tested; complete power units are pretested before shipment.

Insure Predictability — Vickers designs and builds systems which meet the most rigid performance specifications including predicted ambient weather, temperature and other conditions.

Reduce Field Inventory — As far as possible, units are designed with components that are commercial "shelf" items. Inventories of warehouse stocks can be kept low because of component and part interchangeability.

How far advanced is your project? If it is in the design and development stage, we can *immediately* place a team of hydraulic specialists in your plant to work with your engineers. If it is in the "breadboard" stage, let us give you an alternate proposal. On many applications we have suggested much improved power units at attractive production-line prices.

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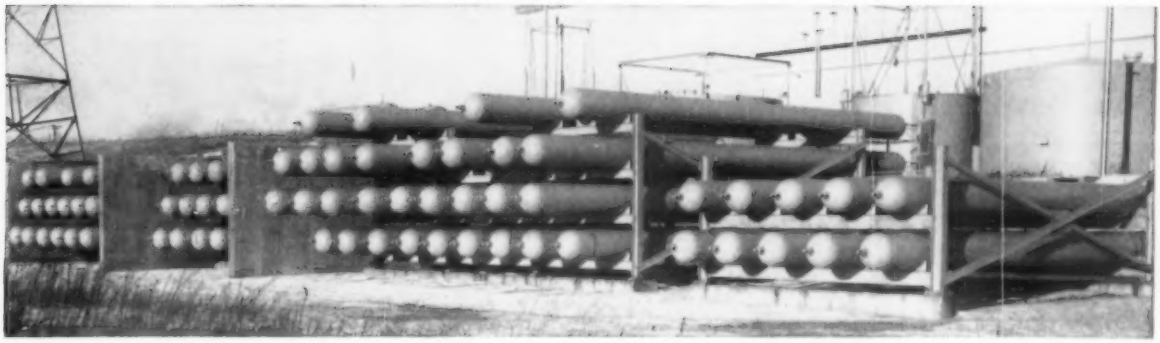

National Seamless Steel Cylinders

store oxygen, hydrogen and nitrogen

The Distribution Transformer Department of the General Electric Company, Pittsfield, Massachusetts, is presently using seventy-six 109.5-cu.-ft.-capacity National* Seamless Steel Cylinders to store oxygen, hydrogen and nitrogen at 947 psi. Each cylinder is 24-inch O.D. x .500-inch wall. The gases are used for testing purposes and for preparing transformers for shipment.

No matter what your gas storage problem, you can count on the strength and dependability of USS* National Seamless Steel Cylinders. Each one is pierced from solid billets of high-quality steel and subjected to a rigid hydrostatic test before leaving the mill. If you have a storage or pressure vessel problem, let us solve it for you. Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

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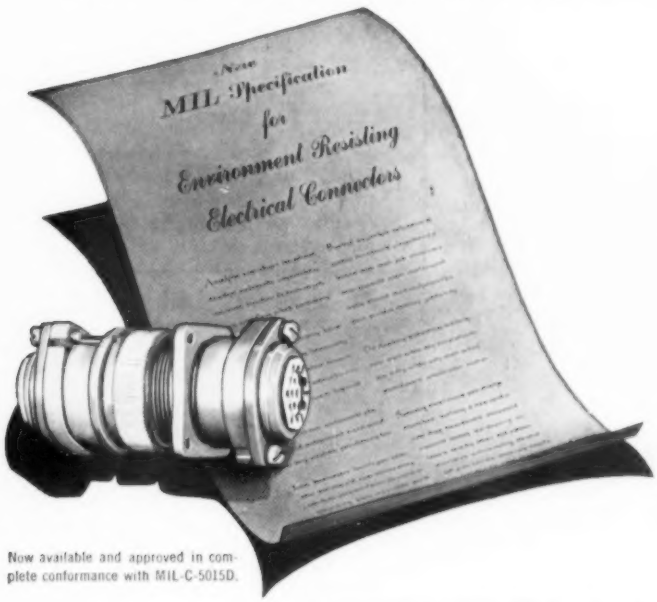
NEW BENDIX MS-R ENVIRONMENT RESISTING ELECTRICAL CONNECTOR



Now available and approved in complete conformance with MIL-C-5015D.

This new connector answers the demand from the aircraft industry for a shorter, lighter and more reliable environment resisting connector. This connector will inactivate practically all other MS types and the Military has assigned a new class letter R to insure incorporation of this better connector in all new designs.

An important reliability feature of the new MS-R connector is an "O" ring at the main coupling joint which provides for the best possible sealing and more positive inter-facial compression and assures complete performance compatibility among all approved MS-R connectors. Establishment of the MS-R connector as the "universal" military connector is testimony to the record of previous MS environmental resistant connectors using resilient inserts as pioneered by this Division. In the Bendix* connector, wire sealing is accomplished by an exclusive slippery rubber grommet which permits convenient wire threading and grommet travel over wire bundles.

Write for more complete information on this latest addition to the ever-growing family of Bendix electrical connectors.

*TRADEMARK

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400,000 G-lbs.

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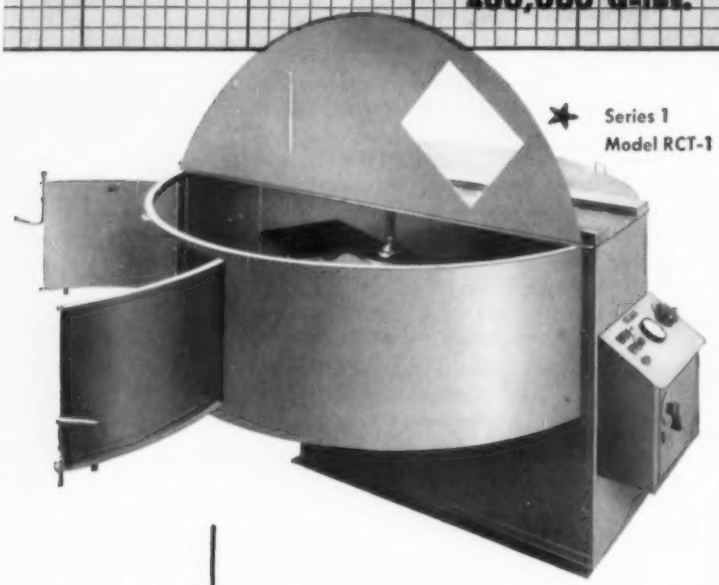

★ Series 1
Model RCT-1

FULL RANGE of 8 MODELS AVAILABLE

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G-rating: 1 to 150
Test radius: 18" to 46"
Specimen: 30-100 lbs.

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G-rating: 1 to 150
Test radius: 96" to 240"
Specimen: 300-600 lbs.

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G-rating: 1 to 100
Test radius: 264" to 420"
Specimen: 2000-8000 lbs.

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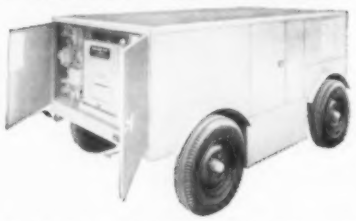
ACCELERATION TEST MACHINES

The Rucker Company, 4709 San Pablo Avenue, Oakland, California

• **HI-PRESSURE GAS BOOSTERS**

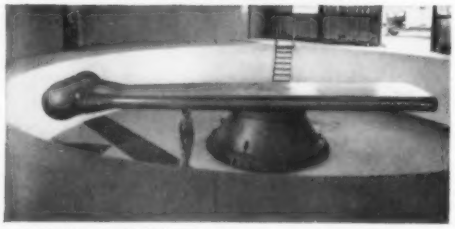


Stationary or portable high pressure gas boosters for compressing helium or nitrogen up to 6000-10,000 p.s.i. for missile development and production testing or flight line checkout.

• **TEST BENCHES**

Standard or custom designed stationary or portable test benches for precision testing of all types of hydraulic or pneumatic components and systems.

★ **Series 20 Model RCT-21**



View of 22′ radius arm and powerhead installed in test pit. This large Series 20 unit is designed for testing 4,000 lb. specimen at 100 G-rating.

New amplifier battles "noise"

Four-stage junction diode amplifier was developed at Bell Telephone Laboratories by Rudolf Engelbrecht for military applications. Operates on the "varactor" principle, utilizing the variable capacitance of diodes. With 400-mc. signal, the gain is 10 db. over the 100-mc. band.

The tremendous possibilities of semiconductor science are again illustrated by a recent development from Bell Telephone Laboratories. The development began with research which Bell Laboratories scientists were conducting for the U. S. Army Signal Corps. The objective was to reduce the "noise" in UHF and microwave receivers and thus increase their ability to pick up weak signals.

The scientists attacked the problem by conducting a thorough study of the capabilities of semiconductor junction diodes. These studies led to the conclusion that junction diodes could be made to amplify efficiently at UHF and microwave frequencies. This was something that had never been done before. The theory indicated that such an amplifier would be exceptionally free of noise.

At Bell Laboratories, development engineers proved the point by developing a new kind of amplifier in which the active elements are junction diodes. As predicted, it is extremely low in noise and efficiently amplifies over a wide band of frequencies.

The new amplifier is now being developed for U. S. Army Ordnance radar equipment. But it has numerous other possibilities. In radio astronomy, for example, it could be used to detect weaker signals from outer space. In telephony, it offers a way to increase the distance between relay stations in line-of-sight or over-the-horizon communications.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

SOVFOTO

MISSILES IN RED SQUARE SHOW . . .

Why we must be businesslike about Research and Development

To insure its security, the United States must continue to match—or exceed—Soviet technological progress. As General Electric sees it, we can do this only by continuing to re-examine and re-vitalize the way we develop defense products.

In 1958, the United States will spend an estimated $5.6 *billion* on military Research and Development (R&D). The reason: we cannot afford to possess defense equipment that will be "second best."

Our dynamic free nation should be capable of out-planning, out-inventing and out-producing totalitarian nations. Yet, despite large appropriations, we are not doing as well as we might in the R&D field. In many cases, we are not capitalizing on the inherent strengths of our successful, free-enterprise system. To keep pace, we must re-examine our R&D attitudes and methods.

● **R&D funding should be continuous . . . not "stop-and-go."** Now funded on a year-to-year basis, R&D programs are often drastically influenced by short-term political considerations. As a result R&D contractors are hesitant to divert more scientific manpower and facilities to defense projects.

● **R&D responsibility must be pinpointed.** Today, responsibility is often scattered among *many* government and private organizations. Fixing project responsibility on individual prime contractors could mean faster progress—at less cost.

● **Incentives must generate confidence among contractors.** The current incentive level on defense production contracts fails to stimulate private investment in military R&D . . . makes it necessary for the government to fund most R&D projects.

America's military-industrial team is now working to solve these critical problems. But their complete solution will be possible only if the need for a revitalized R&D effort is recognized—and supported—by U.S. citizens. 695-2B

GENERAL ELECTRIC

C. W. LAPIERRE

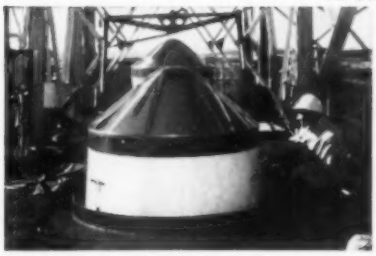
Vice President and Group Executive
Electronic, Atomic and Defense Systems Group, General Electric Company

"If we wish to face the future confidently . . ."

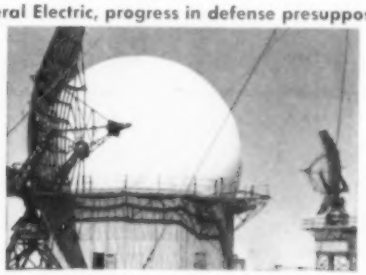
"We must not handicap ourselves with grave doubts and misgivings about the ability of free men in a free economy to out-plan, out-invent, and out-produce a controlled economy.

"If we can continue to subject our methods and our system to critical analysis and appraisal; if we cut through red tape, and simplify prevention-of-mistakes machinery, and eliminate restrictive practices that put the brakes on innovations, to allow for continued bold technological leaps forward; if we organize and administer the work of R&D more effectively—we can face the future, whatever its dangers, adequately equipped, confidently and without fear."

At General Electric, progress in defense presupposes extensive research



RESEARCH FOR MISSILES. Thor nose cone being readied for test flight at Cape Canaveral is a dramatic example of research progress at G.E.'s Missile and Space Vehicle Dept., Philadelphia, Pa.

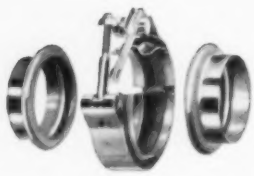


RESEARCH IN RADAR. New height-finding radar developed by General Electric's Heavy Military Electronic Equipment Dept., Syracuse, N. Y., will help improve this nation's air defense network.

RESEARCH IN PROPULSION. Mighty G-E J79 turbojet, powerplant of Convair's supersonic B-58 (above), typifies progress at General Electric's Aircraft Gas Turbine Division, Evendale, Ohio.

This public information message also appears in current issues of NEWSWEEK and FORTUNE.

proved | reliable



duct couplings / duct supports

Couplings provide metal-to-metal seal, fast disconnects, for high pressure, high temperature air ducts. Standard diameters 1″ to 7″, specials to 36″. Separate or integral duct supports. Many materials.

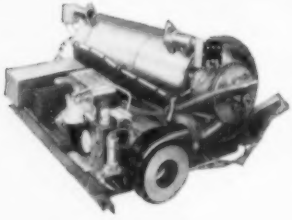
pneumatic controls

Multi-function weight-saving air valves and regulators manufactured to missile tolerances. Adequate staff for fast design and production changes.

Platular heat exchangers*

Combine efficiency of plates with strength of tubes into new economical modular design. Can fit into cramped, odd-shaped spaces in missiles and high performance aircraft for great variety of applications.

**Trademark of Surface Combustion Corporation.*



ground support liquid heaters

Standard units for vehicle, space, and fuel transfer applications. Available in capacities from 90,000 to 1,000,000 Btu/hour and can be combined easily for greater output. Now in service in a wide range of ground support equipment.

Janitrol development and test facilities provide proof in advance of reliable performance in service.

Contact your Janitrol representatives when you need components or systems for heat transfer or air control. Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio.

JANITROL

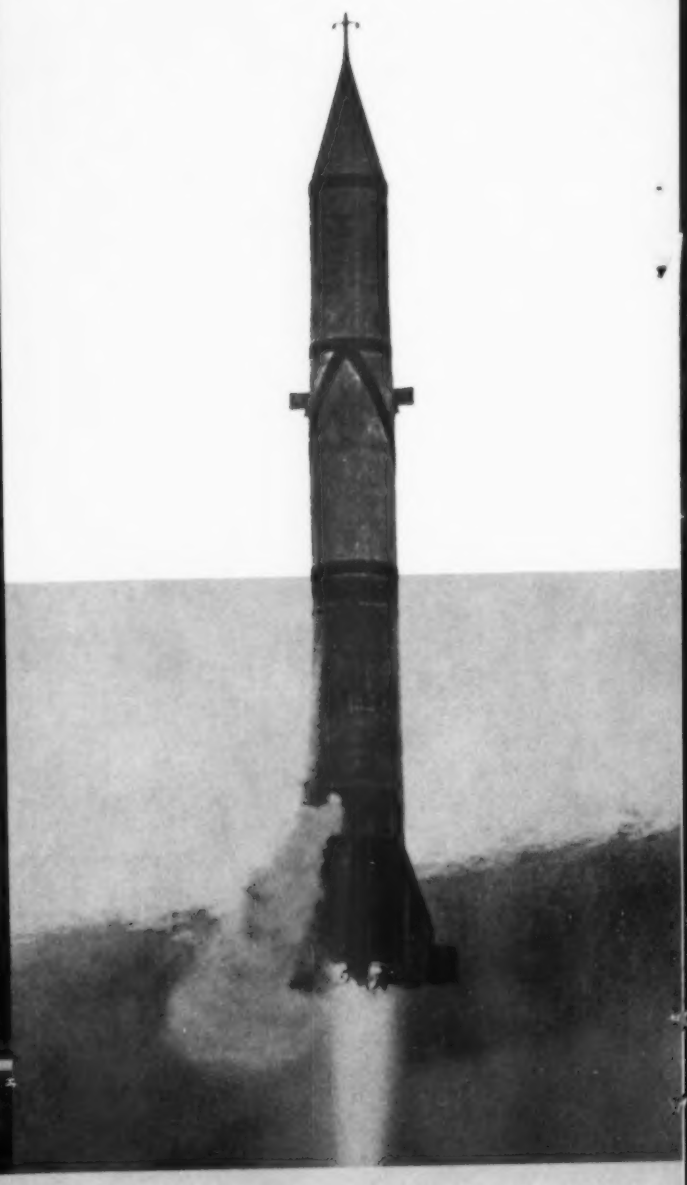
pneumatic controls • duct couplings & supports • heat exchangers

FORD INSTRUMENT CO.
DIVISION OF SPERRY RAND CORPORATION
Long Island City 1, New York

MISSILE SYSTEM CAPABILITIES

FORD INSTRUMENT

JUPITER JUPITER C REDSTONE



missile experience...

includes systems, subsystems and components for many of our country's most advanced missiles

Ford Instrument Co. is currently engaged in research, development, and production on a wide variety of missile projects. Notable among these are the complete inertial guidance and control systems for the Army REDSTONE and JUPITER missiles; many such components for the satellite-launching JUPITER C; launching and control order computers for the Navy's TERRIER and TARTAR missiles; Air Force missile projects, including a no-gimbal inertial system; and a wide variety of ground support and production test equipment.

Today, Ford Instrument has the experience, facilities, and capabilities to enable it to undertake complex missile contracts of every type from component or subsystem to complete weapons system. And, as a Division of Sperry Rand Corporation, Ford Instrument's own weapons skills are backed up by the resources of a vast and diversified organization of complete technical and financial responsibility.

TERRIER Missiles on U.S.S. Boston. Ford Instrument-built computers solve launching and control order problems for this beam-riding missile. U. S. Navy Photo.

U. S. Army JUPITER (left) and REDSTONE Missiles. Cover shows satellite launching JUPITER C. The guidance and control systems for these ABMA missiles were developed and produced by the scientific team at the U. S. Army Ballistic Missile Agency and Ford Instrument Co. U. S. Army Photos.

More than four decades of military systems engineering insure operational equipment . . . whether systems, subsystems or components

FORD INSTRUMENT missile abilities

A unique combination of electronic, electrical and mechanical skills, devoted since 1915 almost exclusively to furtherance of military science, is the basic strength of Ford Instrument Co. Almost all of Ford Instrument's existence has been devoted to research, development and production of highly complex equipment, with laboratory precision and accuracy, yet able to withstand the rigors of military environments.

The proven reliability and extreme accuracy of the REDSTONE and JUPITER missiles, which employ guidance and control systems built by Ford Instrument—as well as the record of the JUPITER C—indicate clearly the company's capabilities in the area of guidance and control.

Another recent example of this type of work is Ford Instrument's design and manufacture of intricate warhead safety, fuzing and arming devices capable of withstanding the roughest environments. Few manufacturers are willing or able to undertake projects such as this and to carry them to completion. Ford Instrument has earned the reputation—which we are proud to acknowledge—of being able to do the "toughest jobs" in missile development and manufacture.

Contracting agencies or industries, with requisite security clearance and "need to know," are invited to examine further Ford Instrument abilities in difficult phases of missile research, development and production . . . whether for complete systems or specialized subsystems and components.

Warhead devices for missiles and other modern weapons. This precision warhead device (inset) made by Ford Instrument, successfully withstood atmospheric re-entry in the nose-cone of an Army JUPITER missile, shown here shortly after recovery from ocean.

Stable platforms. Technicians here are performing test operations on a stable platform for the U. S. Army JUPITER Missile; these platforms are in quantity production at Ford Instrument.

Launching and control order computers for TARTAR Missiles. Electronic and electromechanical portions of this all-transistorized modular computer are shown at left and right.

Actuators for jet vanes, air control-surfaces. This rotary actuator is driven by 1 hp d-c servo motor (shown in foreground with cable attached). Both motor and actuator are made by Ford Instrument.

Missile-borne inverter. Vital missile component gets rigorous, precision performance checkout at console. All of the missile products delivered by Ford Instrument undergo full and complete testing procedures.

Missile-borne computers. Ford Instrument computer experience covers every phase of ballistic missile guidance and control. Typical is this control computer, shown during test, for U. S. Army JUPITER.

Specialized gyros and accelerometers. Ford Instrument pioneered in the quantity production of air-bearing gyroscopes and accelerometers. Air-bearing gyro here undergoes final test in special Ford-built test equipment.

Ground support equipment. Here pre-launch computer undergoes final adjustment. Modular techniques enabled this unit to be produced and delivered in less than 6 months.

current missile projects and equipment

SYSTEMS

- Inertial guidance and control systems and related ground support equipment
- No-gimbal pure integration inertial system
- Launching and control order computers
- Command guidance systems (for both missile and drone applications)
- Trajectory data system
- Missile velocity indicating system for test range applications
- Target locating system
- Radar target prediction and interpretation systems

SUBSYSTEMS (Missile-Borne)

- Safety, fuzing and arming devices
- Stable platforms
- Computers (control computers, guidance computers)
- Programming devices
- Inverter-regulators
- Transmitters

GROUND SUPPORT EQUIPMENT

Maintenance area, launch site and monitoring equipment, including:

- Impact prediction computer
- Aiming correction computer
- Pre-launch computers
- Test panels for computers and stable platforms
- Shipboard dynamic testers
- Monitor panels for guidance, stable platforms, alignment, and laying
- Test fixtures for a wide variety of components
- Combined sensor displays

PRODUCTION TEST EQUIPMENT

Systems and component test equipment including:

- Special environmental test units
- Quantity production test units
- Planetary test stands

SPECIALIZED COMPONENTS

- Gyroscopes
- Accelerometers
- Actuators
- Mechanical integrators
- Transistorized amplifiers
- Relay packages
- Computer modules, both analog and digital, for a variety of missile problems
- Timing devices
- Shipping and storage containers

Drafting. One of Ford Instrument's many drafting departments, where topflight design draftsmen and technicians support research and development and also produce production drawings.

Technicians perform final checks on stable platforms for U. S. Army REDSTONE Missile in ultra-clean assembly area.

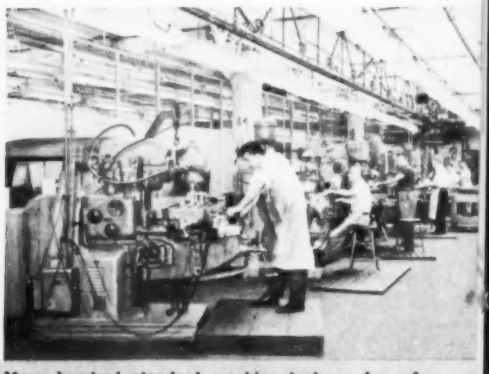
FORD INSTRUMENT

Extensive production and laboratory equipment implement engineering skill

Ford Instrument physical facilities make it one of the largest high-precision shops in the United States, fully equipped to handle every phase of development and production of complex missile systems. Initial studies, research, development, design, prototype construction and testing, final quantity production and quality control are expedited and facilitated by the most modern and highly developed equipment available for precision work.

Contracting agencies and industries possessing requisite security clearance are invited to make an on-the-spot inspection of Ford Instrument facilities.

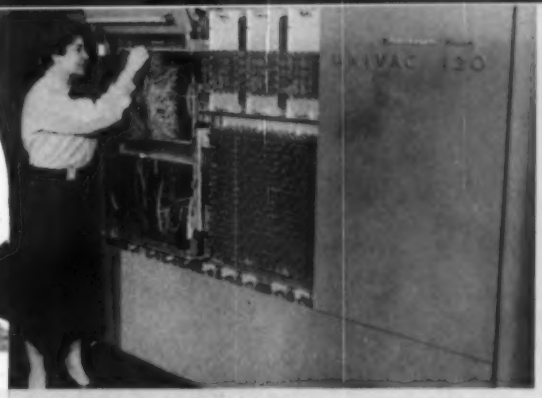
Equatorial test stand, built by Ford Instrument for its own laboratory facilities, is used for conducting basic drift error research. This type of unit can also be built to contractor order.



Many hundred standard machine tools, a few of which are shown here, are available at Ford Instrument for missile applications, as well as a wide variety of special machine tools.

Missile-borne tape programmers being assembled. Continuous development in this field is under way at Ford.

Air-bearing gyro accelerometer is tested here in Ford designed and built special fixture.

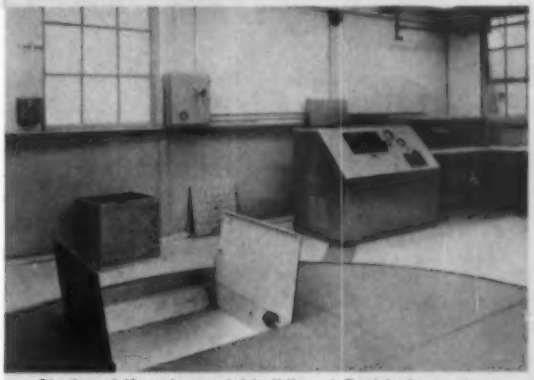


"Univac" computer is one of the general-purpose high-speed digital computers at Ford Instrument for engineering computations.

missile facilities

Typical of Ford Instrument Facilities:

- More than 30 laboratories for research, development and design in electronics, hydraulics, magnetics, mechanics and nucleonics, including fully equipped, ultra-clean gyro facilities.
- Advanced digital computing facilities with high-speed general purpose computers, including a Remington Rand "Univac." Ford Instrument scientists also have access to computing facilities of the Remington Rand Univac Division.
- An engineering shop, as large as many small manufacturing concerns, staffed by expert machinists and technicians, working under direct engineering supervision. The company also has fully staffed and equipped "short run" and prototype shops.
- Full production facilities—machine tools, shops, finishing and inspection facilities—for *large-scale* precision manufacture.
- A series of "clean rooms" for assembly of missile components. These rooms are dust-proof, temperature and humidity controlled areas with full environmental control procedures.
- Complete, elaborate environmental and other test facilities.



Giant centrifuge in special building at Ford Instrument can attain 60G's. Complete stable platforms—as well as components—are tested in this unit.

Vibration testing of missile component. Such tests duplicate inflight environments that components undergo when missiles are fired.

A special machine is used to mill irregular internal contours by an "electrical discharge" method, with extreme dimensional accuracy.

Technician grinds gyro part to a length within 20 millionths of an inch—typical of tolerances being met in missile work at Ford Instrument.

Engineering Shop. This shop makes breadboard models and other experimental products. It has much specialized equipment, e.g., toroidal coil winders, lapping equipment, in addition to standard machine tools.

Over four decades

of exacting weapons

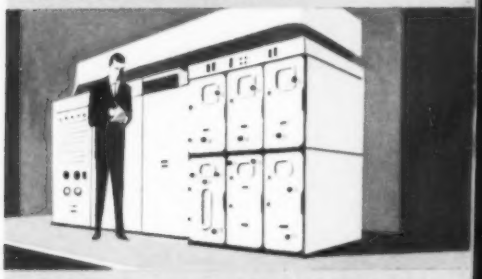
control systems

FORD INSTRUMENT related experience...

Ford Instrument Co. has been devoted to weapons control since its inception, originally pioneering computers and other automatic equipment for direction and control of naval gunfire. Today, Ford Instrument develops and produces equipment of wide variety for every branch of the armed forces and the U. S. Atomic Energy Commission, both directly and as a subcontractor through major manufacturers. The illustrations here give a small cross-section of the many hundreds of activities (other than missile) under way at Ford Instrument.

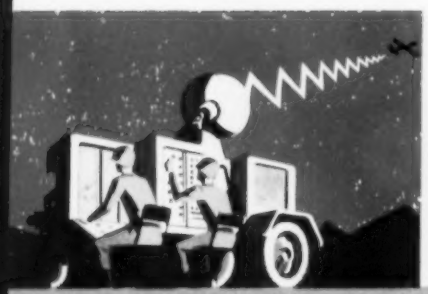
Ford Instrument welcomes inquiries from responsible contracting agencies in government or industry. Liaison engineers are available to discuss specialized requirements or to assist in generation of requirements for any service.

Navigation computers. Ford Instrument develops and produces automatic navigation systems for both U. S. Air Force and U. S. Army —for aircraft and surface vehicles.

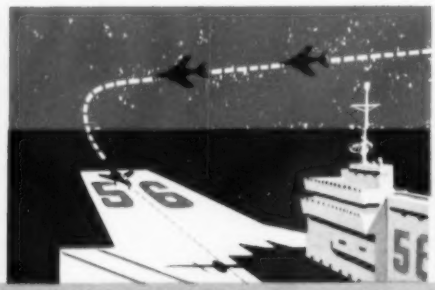


Special-purpose computers. Ford Instrument computers are in wide use in all branches of the armed forces.

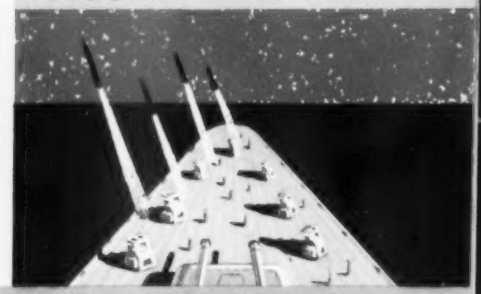
Telemetering and radar systems. A variety of projects at Ford Instrument range from "data-link" and other high frequency techniques—to radar intelligence interpretation and prediction projects.



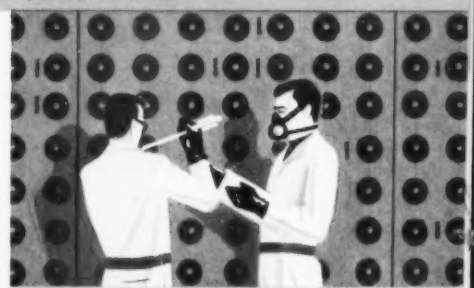
Drone control. Battlefield surveillance aircraft are remotely controlled by Ford Instrument system (radar, transmitting, computing and plotting equipment).



Mission control systems. Latest results of operational research and linear programming theory are implemented by Ford Instrument techniques.



Rocket and gunfire control. Ford Instrument has developed and produced a tremendous variety of fire control equipment for naval and land-based guns and rockets, as well as torpedos and missiles.



Nuclear development. Ford Instrument nuclear activities include reactor designs, instrumentation, control systems (including studies of digital techniques in reactor control) and highly classified weapons projects.

FORD INSTRUMENT CO.

DIVISION OF SPERRY RAND CORPORATION

31-10 Thomson Avenue, Long Island City 1, New York

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29 West 4th St.	Redstone Arsenal	260 South Beverly Dr.
Dayton, Ohio	Huntsville, Ala.	Beverly Hills, Calif.

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T. KEITH GLENNAN

Director, National Aeronautics and Space Administration

America in the Space Age

The NASA will have a vital rôle in future activities in this era

Dr. Thomas Keith Glennan, Administrator of the National Aëronautics and Space Administration, has had a distinguished career in business, education, and research. Born in North Dakota, he was graduated in electrical engineering from the Yale Sheffield School of Engineering in 1927.

His first affiliations were with the new talking-motion-picture industry. He later became assistant general service superintendent for Electrical Research Products, a subsidiary of Western Electric Company. In 1935 he joined Paramount Pictures, Inc., in Hollywood, becoming studio manager in 1939. He served briefly as an executive with Vega Airplane Corporation in 1941, returning to the motion-picture industry as studio manager of Samuel Goldwyn Studios.

Dr. Glennan joined the Columbia University Division of War Research in 1942, serving through the war, first as administrator and then as director of the U. S. Navy's Underwater Sound Laboratories at New London, Conn. For these services he was awarded the Medal for Merit.

At the end of the war he became an executive of Ansco, in Binghamton, N. Y. From this position he was called to the presidency of Case Institute of Technology. During his presidency, he also served from October 1950 to October 1952 as a member of the Atomic Energy Commission.

Dr. Glennan has been extremely active in national affairs. He is chairman of the board of the Institute for Defense Analysis, a member of the boards of the National Science Foundation, and the Council on Financial Aid to Education, and a member of the General Advisory Committee of the AEC.

SCIENTIFIC and technological advances piling up in rapid succession and unbelievable numbers have raised the tempo of ideas on how to explore space. Several years ago, serious study of satellite explorations and space travel was carried on only by a few small groups such as the German scientific team at Redstone Arsenal and members of the American Rocket Society.

Now hundreds of science engineering teams are entering the field, and proposals for earth satellites, space platforms, rocket ships, trips to the moon and to Mars, multiply yearly. Each proponent can show how his project is assured of success and how it will revolutionize something or other if only the Government will provide 5 or 10 billion dollars for the next few years.

Within this fantastic framework the armed forces have been forging ahead, taking advantage of the immediately feasible developments while watching closely all the futuristic schemes that require "just a few break-throughs" to become workable. In their efforts to maintain the Nation's defense at a level proportionate to technical advances, the military on their part have led the way in developing many new tools and techniques.

SUCH developments have excited the astronaut to leap ahead mentally to Mars before a Vanguard can be put in orbit without failures or an X-15 has proved man's ability to survive ultrasonic speeds.

Thus, the Congress, under pressure for vast sums to push both defense and science into outer space, and somewhat overawed by the Sputniks, has established a National Aëronautics and Space Administration to study all nonmilitary astronautical proposals and select and direct the programs of greatest promise within budgeting limits and reasonable time scales. It is expected that in many areas of endeavor NASA programs will have to lean heavily on devices perfected by the Defense Department, and at all times the dividing line between civilian and military projects will be hazy.

It is fortunate that the new activity is not forced to grow from scratch but has been formed from the 43-year-old National Advisory Committee for Aëronautics. The latter is a time-tried, successful organization with a world-renowned record of solid achievement in technological development. It not only contributes a large staff but many laboratories—the three largest being at Langley Field, Va., Cleveland, Ohio, and Moffett Field, Calif.

Thus the Nation should expect that no wasteful or harebrained schemes will be undertaken and that projects will be processed promptly.

THE position of NASA, supposedly a civilian activity, relative to the Department of Defense is not entirely clarified. A number of projects formerly under the Department of Defense already have been released to NASA, including Vanguard, lunar probes, and a million-pound thrust rocket engine.

However, the suggestions to transfer scientists and laboratories to NASA from the Army Ordnance Missile Command, which would wreck a vital part of our defense program, shocked and surprised a large segment of the Nation. Dr. Glennan, Administrator of the National Aëronautics and Space Administration, is faced now with the task of trying to calm the troubled waters and keep a sensible balance between space ventures and weapons for the national defense.

Active Air Defense

It is the task of the men and machines of the North American Air Defense Command to be ready every minute of every day to detect, identify, intercept, and destroy any attacking aircraft or missile

Gen. Earle E. Partridge, U.S.A.F.

A basic problem in air defense is how to be ready to react immediately against an attacking force. This has been true ever since the first military use of air power. But the problem has grown tremendously both in size and complexity, and it will continue to grow in direct proportion to the technological advances in air and nuclear sciences.

Jet bombers, flying at double the bomber speeds of World War II, already have greatly lowered the time available for the defense to carry out its functions of detection, identification, interception, and destruction. And when we move into the intercontinental ballistic missile era, this time will be slashed to seconds.

The North American Air Defense Command (NORAD) system in existence today has been built over a period of ten years and at a cost of many billions of dollars. An integrated, Canadian-United States command, NORAD comprises the forces of the Royal Canadian Air Force and the U.S. Army, Navy, and Air Force.

IT is spread across the North American continent from the edge of the polar icecap to the Mexican Border and from east to west far beyond the edges of the continent. The headquarters in Colorado Springs is the hub and nerve center.

Our efforts in NORAD are governed by the knowledge that an attack could come at any moment and that the first attack could end the war. What we can do or what forces would be provided to us after an attack is of little interest. We must be ready at this minute—and every minute of every day—to counter the first attack. In other words, our daily routine is to be prepared to fight a major battle.

General Partridge is Commander in Chief, North American Air Defense Command, Ent Air Force Base, Colorado Springs, Colo.

Viewing the situation in its simplest terms, two basic resources are necessary in order to attain this preparedness: men and machines. New and more efficient weapons are constantly being and will continue to be developed. The personnel problem, however, is one that is always with us and one that NORAD shares with other commands in all the services.

How can we keep high turnover rates in the skilled technician fields from degrading the high level of readiness essential to air defense? Currently the air-defense system has only twenty-five per cent of the supervisory personnel it should have, seventy-five per cent as many fully qualified technicians, pilots, and other flight personnel as are needed, and over three times as many apprentices as should be present in a well-balanced organization.

Recent legislation revising the military pay structure should go far toward retaining skilled personnel, but we also should realize that we may never be able to compete on an equal footing with industry for the essential technicians.

Taking our resources as they exist, the ideal obviously would be to keep all of them ready for instantaneous action at all times. But equally obvious is the fact that having all the force at instantaneous readiness for more than short periods is impossible.

WE have our units in place and our weapons and crews on hand. So far, however, our technology has not developed equipment that will not wear out or break down. New tubes and other parts have to be put into the electronic components of our aircraft and missiles. The engines in our interceptors have to be repaired or replaced. By the same token, all the crews cannot remain at battle stations constantly. They must have time to be with their families, time for rest and recreation.

Therefore, we have to settle for being as prepared as possible within human and equipment limitations. We keep a small number of missiles and interceptors ready to fight immediately at all times. The remainder of the force is kept on whatever status of alert seems advisable in terms of the current threat estimate and training, maintenance, and personnel requirements.

This means taking a calculated risk that enemy bombers will not appear suddenly over a target, but that we will get at least a short warning. During this warning time, we can bring our entire force up to a state of immediate readiness.

Our tactical units work something like the city firemen. Part of the force is ready at an instant to rush to a blaze. The rest can be called out on short notice if needed. To illustrate, currently at most interceptor bases we keep some aircraft on 5-minute readiness, more on a 1-hour status, and the rest ready to go within 3 hours. Approximately a fourth of the Army Air Defense Command missile units are ready to fire within fifteen minutes, another fourth can be ready within a half hour, the balance within three hours.

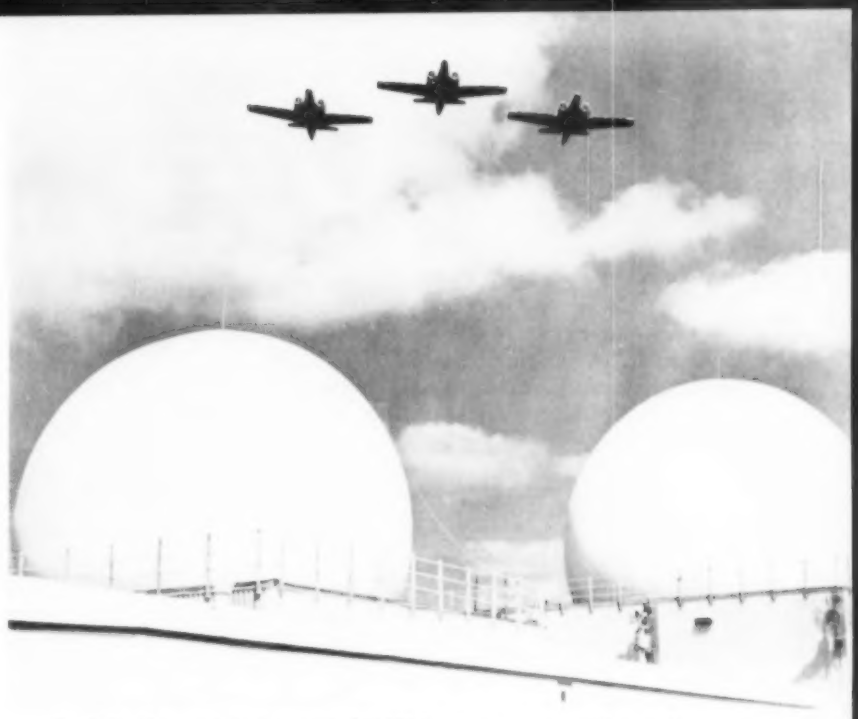
To meet these daily alert requirements, we have special procedures and facilities. For the interceptor force, the usual air base with its barnlike hangar and with servicing facilities and crews' quarters somewhere on the base would not do. Special alert hangars were built with several bays—each bay large enough for only one airplane. Quick-opening front and back doors were provided on each bay.

Normal servicing needs were put into the hangars, along with quarters for both the maintenance and flying crews. A loud klaxon calls the men to their planes. Other crews live on the base or close enough to reach it within their assigned alert time.

The Army missile batteries work in somewhat the same manner. Combat alert crews man each site around the clock. A siren calls them from their on-site quarters to battle stations. The remainder of the crews live near by, within ten to fifteen minutes of the site whenever possible.

To get the time needed to bring our entire force up to immediate readiness, we rely mainly on our radar detection system. In order to lengthen the vital interval between warning and attack, we have located the warning line as far away from the target areas as geographically possible.

Stretching for 3,000 miles along the northern rim of the continent in the Canadian Arctic is the Distant Early Warning (DEW) Line of radar stations. The Navy guards the flanks of the continent by continuing this line out to sea with radar-equipped destroyer escorts and WV-2 Super Constellations. These mid-ocean lines stretch from the Aleutians to the mid-Pacific and from Newfoundland to the mid-Atlantic.

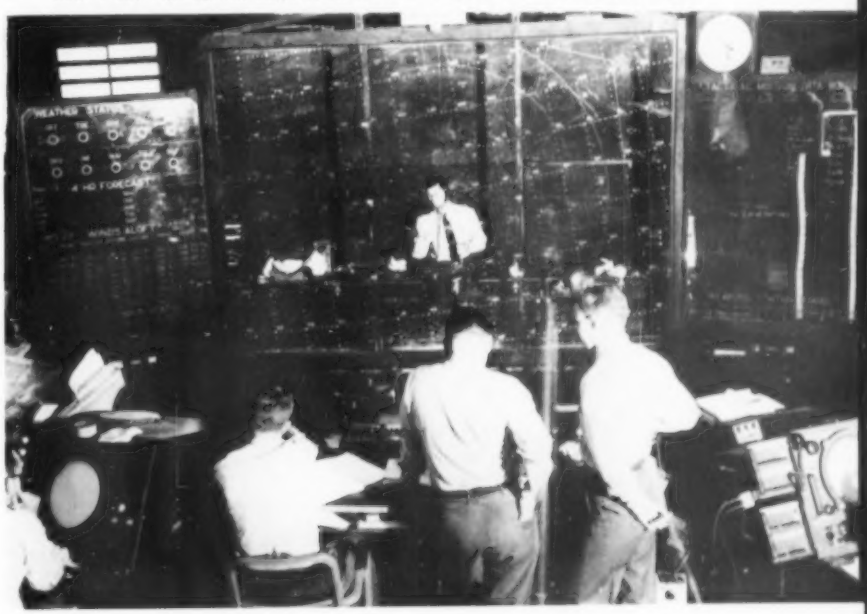


Symbolic of ground-air teamwork, CF-100 interceptors fly over domes of a North American Air Defense radar installation along the Pine Tree Line.

Behind the DEW Line, some 600 miles south, lies a second radar chain, the Mid-Canada Line, built and manned by Canadians. A third radar net, the Pine Tree Line, built and manned jointly by the U.S. and Canada, weaves its way across southern Canada. Finally, back of the Pine Tree posts is a massive interior network of radar stations, including lines of off-shore Navy picket ships, Air Force RC-121 Super Constellations, Navy ZPG-2W blimps, and, in the Atlantic, radar platforms called Texas towers.

Our system thus is one of early warning plus defense in depth. It provides not only warning of the approach of the enemy, but also ability to track him continually along his line of approach to target areas.

Airmen plot aircraft movements at a NORAD radar site, maintaining a 24-hour-a-day vigil against surprise air attack on the North American Continent.



To be of any value, the information from the detection system must be collated and evaluated. It must be transmitted rapidly from place to place and displayed in a form that will enable commanders to make an up-to-date and continuous estimate of their situation and, if we are attacked, to direct the air battle. This requires a vast communications network tying together the whole system of radars, weapons, and command posts from the DEW Line to Air Defense Command headquarters in Colorado Springs.

To process the data, we have had to rely up to now on a manual system of observing, plotting, and transmitting the information. To speed this up and to reduce human error, we recently standardized the methods and facilities and added mechanical and electronic aids.

VERY shortly, however, we will have a whole new electronic data-processing system that will speed up this function many times. This is the Semiautomatic Ground Environment (SAGE) System. SAGE will combine current detection techniques with the use of high-speed electronic digital computers. It will be able to receive, process, and display air surveillance information and, as directed, send guidance instructions or information to weapons or commands. Working in conjunction with SAGE will be a missile fire-direction system, the Missile Master.

Detection of aircraft must be followed by rapid and unerring identification. After a hostile attack is believed imminent or enemy aircraft are detected, identification is less of a problem. Provisions have been established for the immediate grounding or diverting of all civilian and nontactical military aircraft by the Civil Aëronautics Administration in the United States and the Department of Transport in Canada. Then almost anything penetrating the early-warning radars from known enemy directions can be considered hostile.

However, an enemy undoubtedly will try to make his first attack with as much surprise as possible. One minute we could be at peace; the next minute we might find ourselves to be the target of already-committed enemy aircraft. The air space over the continent will be filled with the usual amount of friendly air traffic. The enemy will try to use this traffic as a screen. Therefore, as a matter of daily routine, we must know the identity of every aircraft over or coming into the continent.

Currently, identification is accomplished largely through a manual system of flight plan checking and matching. Certain critical areas of the continent have been designated as Air Defense Identification Zones. When a pilot plans to fly into or through one of these zones, he files a flight plan showing his destination, heading, altitude, and time. When the detection system picks him up, the track is checked against the flight plan. If they match, allowing some time and distance tolerance, the attack is considered friendly. If not, or if there is any doubt, an interceptor is scrambled to identify the plane visually.

For aircraft entering the country from overseas, the difficulties of precise navigation over the ocean necessitates additional requirements. The pilot is assigned a corridor to enter and follow to a navigational beacon. If he misses the corridor or strays from it, he is challenged to give a code word or to perform a maneuver given him in a sealed envelope at his point of departure.

Up to this point, I have touched briefly upon our operations during normal preparedness conditions—our daily routine. At the first indication that an attack is coming, we would move into a higher state of preparedness.

For example, if intelligence sources indicated any possibility of an attack, we might go on an increased-readiness status. Under this condition, we would place more weapons on an advanced state of alert, defer most training, intensify internal security measures, and make ready extra communications lines.

Should we then get more definite information of an attack, or even suspect that an attack is imminent, we might go to an air defense readiness or an air defense emergency status. These conditions would place the system in a state of maximum operational preparedness. Our aircraft and missiles would be warmed up, and in certain areas planes would be sent up on combat air patrol.

The CAA would order the grounding or diversion of air traffic. The Federal Communications Commission would direct the closing down of radio and television stations so as to prevent the enemy from homing on them. Available fighter forces of the Navy, Air National Guard, and Air Force (outside the Air Defense Command) would be called up and put on alert.

Of course these stages of preparedness are not necessarily followed in 1-2-3 order. We might go directly to an emergency condition, our planes and missiles ready for immediate employment against the enemy air attacker.

THESE then are the mechanics of the system built to defend against the manned bomber attack. But now a whole new problem faces us. To meet an ICBM attack our system will have to speed up to react in seconds. We must get very-long-range radar that can detect missiles coming, link these radars with other radars and command posts farther back with rapid communications and computers, and have antimissile missiles ready to intercept the enemy missiles.

All along the line these problems are being worked on. Many promising developments have been made and more will come. In the meantime, the NORAD system has to be maintained in a state of constant readiness.

In summary, we must dispel any concept of defense which conjures up a mental picture of a relatively static or passive procedure, as contrasted with aggressive action.

Our mission is active air defense—which comprises all measures designed to discover and destroy hostile aircraft and their crews. On our ability to accomplish this mission, to react promptly without a moment's delay and to employ effectively the men and weapons we have at the time an attack comes, will depend the future of our country—and perhaps the peace and security of the rest of the free world.

Time, Money, Manpower

For a strong national defense we must continue to compress time, invest many dollars for the know-how and facilities to obtain quality weapons, and channel our brain power to greater creativity

Lieut. Gen. S. E. Anderson, U.S.A.F.

IN the scientific and technical campaign of the cold war in which we are engaged, time is a resource not to be squandered. This can be particularly appreciated when we look at the rate of progress made in science and technology—but one evidence of the progress made by mankind throughout the history of the world.

In his book, "A Guide to Earth History," Richard Carrington put it this way: "If we imagine the whole of earth's history compressed into a single year, then, on this scale, the first eight months of the year would be completely without life. The following two months would see only the most primitive of creatures, ranging from viruses and single-celled bacteria to jellyfish, while mammals would not have appeared until the second week in December. Man, as we know him, would have come onto the stage at about 11:45 p.m. on December 31st. The age of written history would have occupied little more than the last 60 seconds of the clock."

Expanding this condensed time cycle a bit, J. Lewis Powell, of the Office of the Assistant Secretary of Defense for Supply and Logistics, illustrates the phenomenal rate of progress in another way. He relates it to the years lived by many adults today—about 50 years as an average.

This would mean that 10 years ago man stopped living in caves; 5 years ago some one invented picture writing; 2 years ago Christianity started; 5 months ago the printing press was invented; 10 days ago electricity was discovered; yesterday the Wright brothers flew the first plane; TV was invented an hour ago; and jets came into being within the last 5 minutes.

Please note that on this basis almost everything that makes up our material world, from inside plumbing to jets and missiles, would have been invented within the last twenty-four hours.

While progress is being made rapidly, the effort and engineering man-hours required for the design and development of new weapon systems have increased. For example, the B-17 of World War II which was laid down in design about 20 years ago required 200,000 man-hours to bring to its first production flight.

The B-29 and B-36 each required about 15 times that number of man-hours; the B-52 required about 35 times the man-hours; and the B-70, the new chemically powered bomber being built by North American, will require over 70 times the man-hours needed for the design and development leading to the first production flight of the B-17.

This increase in the number of engineering man-hours reflects on the next facet of our discussion—that of money. Today we talk of research and development programs in terms of billions of dollars. The research and development portion of ARDC's program is at a level of about $700 million for the present fiscal year. Our entire program is well over $2 billion.

YET a little over a decade ago there were few things we referred to in terms of millions, let alone billions. Such "astronomical" figures were reserved for discussions of microbes and bacteria.

How much is a billion of anything? Do you realize, for example, that since the year 1 A.D. we have not quite ticked off one billion minutes!

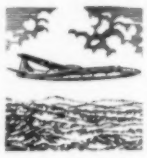
Truly, over half a billion dollars for research and development in a year represents a large investment by the American taxpayers. Too often, unfortunately, the tax bill is paid with a feeling of futility since the general impression is that defense dollars are poured into a bottomless pit—that there is no pay-off or profit to be obtained

General Anderson is Commander, Air Research and Development Command, Andrews Air Force Base, Washington, D. C. This article is based on an address given by General Anderson before a recent meeting of the A.O.A. Missiles and Astronautics Division at Patrick Air Force Base, Fla.

from the investment being made. This, however, is not the case.

One obvious pay-off from defense expenditures is, of course, the strong position of deterrence which we have built and which has maintained our national security. Another and less obvious pay-off of military investment is the benefit to our national economy and standard of living that comes from military research and development programs.

Today, military research and development builds qualitative superiority in military weapon systems and strengthens our defense posture while at the same time making major contributions to our unparalleled standard of living.



Today, home television has come to be regarded as almost a necessity and at the same time a luxury of daily life. Furthermore, it represents a multimillion-dollar industry providing a livelihood for many skilled workers and a stimulus to a sound national economy.

All of this was made possible because of military needs during World War II which dictated the development of radar equipment. This resulted in the development of low-cost viewing tubes which were basic to the production of low-cost home television sets.

THIS same radar development has had even more far-reaching effects. For example, many of our major airlines now use weather radar for safer and more comfortable flights. Radars are available for private boat use—a major contribution to marine safety.

And while many of our speeding motorists may not appreciate being waved to the side of the road by the highway patrol which spotted them through the eye of radar, they nevertheless respect the important rôle it plays in improving road safety in this fast-moving age.

Radar also has gone into the schools. In this day when high-quality instruction is at a premium because of the critical lack of qualified teachers and instructors, closed-circuit television will be a boon to the expanding needs of our educational system. Besides providing a substitute for the shortage of teachers, it makes possible the presence of certain personalities of high esteem in the scientific and technical world in many classrooms at one time. So from a military need has come quite a major contribution to our modern way of life in this Nation.

Another striking example of a military development which has created a civilian industry and a smaller world is in the field of aircraft engines. I am referring to the turbojet engine which is making possible the commercial jet transports to be operating from coast to coast within the next year. The development of the turbojet engine to the point of demonstrating a technically and commercially feasible prototype has taken close to $100 million.

No single civilian airline could have ventured this kind of capital on such a risky idea—the idea of propulsion by a "squirt" of air. Military need, however, demanded that we support this venture. Today, turbojet engines have propelled aircraft like the B-58 at speeds over twice that of sound —or over 1,300 miles an hour.

Such developments will make possible coast-to-coast transportation at close to 600 miles an hour in such commercial airliners as the Boeing 707's, the Douglas DC-8's, and the Convair 880's.

Looking to the future, we are thinking about the development of hypersonic bombers with global ranges of 25,000 miles. These will be manned vehicles launched by rocket boosters and reaching speeds of up to 18,000 miles an hour. Quite possibly, future years may draw from this type of development a rocket transport for commercial use which conceivably could be launched from near-by Cape Canaveral and land in London within the half hour.

THIS is an interesting possibility to contemplate. It is interesting not only in technique but also in what it means in bringing all the people of this earth closer together. Thus, the pay-off in this military development—like others before it—will include sociological as well as commercial gains.

A discussion of benefits to the civilian economy cannot be concluded without making a point of the many highly qualified technicians who have been trained by the military services. Because of the poor pay received, many have given up their military careers for more comfortable and more profitable civilian pursuits.

This loss to the military services has been a gain to the American community for it has brought in vital skills. We hope that the legislation revising military pay recently passed by Congress will help the services to retain the highly trained and skilled personnel they need in carrying out present-day military operations.

There are many other examples of military contributions to daily living. All of them demonstrate emphatically the double benefits of military research and development.

IN addition to the problem of time and money, there is the need for highly qualified people who, by virtue of their schooling, special training, and experience, contribute to pushing ahead the curve of progress.

In this area, dollars alone cannot buy immediately the additional capability we need in well-educated and creative scientists and engineers.

In fact, dollars alone will not necessarily produce the talents we need. Our investments in money and time must be made most wisely in our educational system if we are to develop the scientific potential we require.

Dr. Henry T. Heald, a noted educator and president of Ford Foundation, makes the point this way: "There are only a limited number of people in America who are equipped to be creative scientists. We need to identify them and give them a chance to develop. Scientists cannot be made overnight with any amount of money. They must be produced by the American school system."

I might add further that they must be produced by an attitude in the home as well as in school which encourages hard work and creative thought without the suggestion that ignorance is bliss and that there are easier ways to "make a buck."

Regardless of whether we are engaged in building more ground fire-

power, more sea power, or more air power, we are putting brain power to work. Since our national pool of brain power is limited, it falls to us, then, to encourage young people to train in the sciences which are essential to support our future growth. Such support will give us no tactical advantage in increased capability immediately, but it will give us strategic advantage in the decades ahead when American ingenuity and inventiveness will be tackling even more difficult problems than those which we visualize today.

OUR concern lies not entirely with scientists and engineers. Our concern lies also in the increasing numbers of technically competent people we need to operate and maintain the more and more complex weapon systems and equipment which emerge from the parade of progress. We have a certain potential today for science, technology, and operations support.

Of these, we must make the best use possible; however, we cannot afford to lose any time in also promoting an improved and enlightened appreciation of science and technology in our schools —starting at least at the junior high school level and going on up. We are confronted with the challenge of determining how we can best manage the resources of time, money, and brain power in meeting our national-security needs.

Within the Air Force, this need was visualized about a decade ago. It was then that leaders in the Air Force saw that science and technology would play a rôle of ever-increasing importance in keeping the Air Force ahead qualitatively.

Calling on leaders in American science and management—like Dr. Louis Ridenour, then of the University of Illinois, Gen. Jimmy Doolittle, and Dr. Donald Quarles, then with Western Electric—the Air Force came up with a central-management concept for research and development. The implementation of this concept is the Air Research and Development Command.

Through its integrated management of the activities of its Research and Development Centers across the country, ARDC uses the scientific and technical capabilities of the Air Force and of the country most effectively.

Such organizations as ARDC's Office of Scientific Research located in Washington, D. C., and the European office located in Brussels, Belgium, work closely with the scientific community here and abroad in seeking out new knowledge for application to the development of advanced weapon concepts.

MORE than that, these offices are focal points for continuous interchange of ideas with universities, research groups, and scientists both here and in Europe.

Undoubtedly, scientists and engineers have gained in prestige over the past several months. I hope, however, that this newly regained appreciation is more than just a fad. I get the feeling that right now it is stylish to extol the merits of science and scientists; but I wonder how long this atmosphere will last.

Already, the generally discussed "recession" in our national economy has diverted attention from the far horizons of science and the needs of our national defense to the more "concrete" thoughts of a national public works program.

But even without this diversion we have certain handicaps to overcome in our industrial and military thinking. We must undergo a major revision in our production-oriented philosophy.

FUTURE weapon systems will demand more in quality of concept and design and less in quantity of production. This is counter to our ingrained industrial objective of going into quantity production as soon as possible and sustaining such production as long as possible.

If industry is to be encouraged to engage in development programs which stress quality rather than quantity production, new and more liberal principles of allowable profit must be devised and accepted.

This is an interesting aspect of our progress into the complexities of the space age. It is an aspect which requires thought and study on the part of the legislative and executive branches of our Government and industry, and particularly of the American Ordnance Association.

Turbojet engines powering the Boeing B-47 are an example of a commercially usable military development.

The New Dimension

Development of satellites and guided missiles has opened up the space frontier, and the Science-Industry-Military Team must be ready to exploit its possibilities for peace and national defense

Brig. Gen. J. A. Barclay

THE Army's interest in rockets, guided missiles, and earth satellites logically derives from the mutually beneficial relationship between the military and the sciences. Almost everything of material use to the military for defense purposes has come from science.

This intimate coöperation dates back to the development of gunpowder that could be handled safely, stored ready for instant use, and that would function with adequate reliability. The swift technological advances of recent years, exploited for military purposes, have added to the complexity of modern weapons and lent greater urgency to the coördination of scientific and military developments.

Especially is this true in rocketry, which made its advent in military use as early as 1200 A.D.

The successful adaptation of rocket propulsion to military requirements and thence to space exploration has been made possible by three major technological break-throughs. The first occurred in 1926 when the American pioneer, Dr. Robert H. Goddard, launched a liquid-propelled rocket over a distance of 194 feet.

A SECOND and giant step forward came in October 1942 with the successful launching of the V-2 long-range rocket by German missile scientists at Peenemuende. Key members of that group, headed by Dr. Wernher von Braun, are now American citizens employed by the Army in the Ballistic Missile Agency and the Rocket and Guided Missile Agency at Huntsville, Ala.

General Barclay is Commander, Army Ballistic Missile Agency, Redstone Arsenal, Ala. This article is based on an address given by General Barclay before a recent meeting of the Middle-Tennessee Chapter of the A.O.A. Cincinnati Post at Nashville, Tenn.

A third major event occurred on October 4, 1957, when Soviet Russia launched the Sputnik earth satellite, followed on January 31, 1958, by the launching of the Army's Explorer scientific satellite. These events catapulted us into the Space Age. We are in the year 1958 A.D.—Year 60 for the automobile and Year 1 for satellites. We are entering an era when man and the products of his efforts can travel or be transported through the space about our earth. We will soon travel paths which have challenged man since the beginning of time.

As an illustration of this aspect of space utilization, consider the earth satellite which travels its orbit at a velocity in the order of 18,000 miles an hour as a free-falling object without the application of any mechanical, chemical, or electrical source of energy. Explorer I has an estimated lifetime of ten years. By then, in terms of the mileage it will have traveled, its cost will have dropped to one-tenth of a cent per mile.

Explorer III, launched on March 26th, covers about 485,000 miles a day, or something less than 20 orbits around the entire earth in 24 hours.

For purposes of comparison and with the deliberate purpose of exciting your imagination, contrast this performance with the average costs per ton-mile of conventional transport systems. Waterborne freight costs 1.8 cents a mile, rail 2.8 cents, trucks 4.3 cents, and commercial air 4.6 cents.

ADMITTEDLY, the payloads of the Explorers are relatively small, but the point is that the initial fuel energy used is the total power cost. Once an object has been placed in orbit at sufficient altitude, there is exactly the same performance regardless of its mass; that is, it becomes a free-falling object which by kinetic energy will continue in orbit indefinitely at approximately 18,000 miles an hour.

It has been estimated by our satellite developers that six orbiters, equipped with electronic computers, could handle the entire mail volume of the earth. Messages would be flashed to them from ground stations, promptly recorded, and played back over the correct destination. By this method it would require about five minutes to

pass a complete letter from Nashville to an addressee in Washington.

Suppose we substituted cargo for the warhead of a long-range missile and thus transferred it, in the space of a few minutes, from earth's surface to an orbiting space station from whence it could be delivered by gliding reëntry vehicles to any point on earth. This is technically feasible; in fact, we already are considering the application of missile techniques to the spot delivery of men and matériel when the exigencies of combat require fast movement and we are denied access by other means.

In consideration of our future space programs and the early stage of our knowledge, we must not conclude that the practicality of an objective is the only justification for the support of activities necessary to attain it. Often it is necessary to engage in such endeavors with the feeling that if the main objective is not reached, the stimulation provided and the peripheral contributions to our scientific knowledge more than justify the effort.

Who can say what is practical and how far our technology can go? Man in his quest to better himself and his conditions must always be free to reach out into the unknown. He must be free to quest and explore for knowledge without concern as to how it may be applied. His only hope for security lies in progress, intellectual and spiritual.

Let us now turn to a consideration of the relationship of the defense establishment to science and industry. The Explorer projects demonstrated once more that it is entirely feasible and essential to associate military knowledge and capability with purely scientific undertakings to the profit of both.

A friendly working relationship has existed for many years between the armed forces, science, and industry, best exemplified by their intimate association in World War II. When the chips were down and the security of the free world hung in the balance, there was no hesitancy about committing all our resources without exception to win the fight.

We must not delude ourselves into thinking that there is a pure science and a military science. Our technological and scientific advances are brought about by knowledge or the existence of creative manpower; the command of energy; and the availability of materials, techniques, or processes. Those advances which we achieve in peacetime will inevitably be applied in time of war when our security and national being are at stake.

Therefore it is obvious that the know-how and facilities existing within the defense establishment belong to the country and should be employed to the full extent of their availability in the national interest, including the advancement of science.

Any other course would mean duplication and additional spending, not to mention a time lag. The increasing rôle played by technology in our military structure renders it impossible and unwise to attempt to separate the efforts of the scientist from the soldier.

We received instructions from the Defense Department on November 8, 1957, to prepare for the launching of a scientific earth satellite as a contribution to the International Geophysical Year. We launched the Explorer eighty days later and followed up in fifty-four more days with Explorer III. The missions flown in both satellites were assigned by the IGY Committee of the National Academy of Sciences. They included measurements of cosmic-ray intensity, micrometeorite density, and temperatures within and outside the orbiters.

Data are being accumulated and evaluated at the Army Ballistic Missile Agency and the Jet Propulsion Laboratory, our associate in the satellite projects, and exchanged with the Smithsonian Observatory and the IGY Committee.

Additional space projects, again in the scientific area, have been assigned the Army by the Advanced Research Projects Agency of the Defense Department. They involve the launching of two and possibly three more earth satellites, and one and possibly two lunar probes. For these undertakings we will use the Jupiter and Jupiter-C.

We do not overrate our technical accomplishments in the Explorer program to date because little that is new was involved in guidance and instrumentation. But they are of great importance in several respects: they proved out the launching technique, they proved techniques for instrumented space platforms from which men can study the environmental conditions of space, and they helped marshal public opinion in support of an aggressive space program.

THEY also have created problems, particularly in the computing and data-processing areas. So much information is being received from tracking and measuring instrumentation carried in the Explorers that interpreters who refine and evaluate raw data are literally buried in it. Fully automatic data handling and processing techniques must be developed because this problem will be aggravated when satellites

New 160-inch lens optical tracker traces a missile 300 miles away (Army photo).

We do not consider Redstone the

Pershing System.—This is in the in-

be launched from the security of our

are employed for weather observation and communications relay.

More sophisticated orbiters will demand extreme accuracy in guidance systems necessary to achieve precise orbits and in the instrumentation by which the vehicle senses and communicates its environment and position as functions of time. An early goal is the return of a satellite to earth and its recovery from a preselected impact area. This can be achieved by use of retrorocket techniques, but the time of initiation and thrust direction of the retrorocket must be sensed and controlled within narrow limits.

The technical problems involved in more ambitious undertakings, such as lunar probes, call for extreme guidance accuracy. The trajectories of such missions in orbit must be evolved from a multibody problem in celestial mechanics.

FOR example, the lunar-probe trajectory will be influenced considerably by the gravitational effects of the sun. If we hope to get a look at the far side of the moon, the accuracy requirements for such a launching are in the following order:

1. Cutoff velocity of the last propulsion stage must be accurate to within one part in one thousand.

2. The injection angle of the vehicle into the earth-lunar ellipse must be accurate to within one-fourth of a degree.

3. If we do not consider continuous aiming of the launching platform and continuous changes in the initial trajectory program, the instant of firing must be timed to within one or two seconds because the earth is a rapidly rotating firing platform and the moon is a rapidly moving target.

For lunar and interplanetary probes, the guidance problem looks for ultimate solution to the use of on-satellite midcourse and terminal guidance corrective devices employing radio command, infrared homing, inertial guidance, or combinations of them. The basic problems, then, become those of payload weight and communications.

In view of the technological progress achieved in recent years and its accelerated momentum in the missile field, there is no reason to expect that these or other related problems will defy solution.

We can anticipate the reconnaissance orbiter which, in due course, will scan the entire surface of earth. Attitude control will be essential to this development, and investigations in the area are in progress. Proper control of satellite temperatures is required. This involves spacewise and timewise variations in skin temperature.

When sufficient knowledge and experience have been obtained from advancing satellite technology, we shall reach the phase of manned orbital flight. This must be anticipated by finding solutions to such problems as pressurization, supply of oxygen and exhaustion of carbon dioxide, photo synthetic gas exchange, and the effect of sudden decompression. Air Force and Navy medical researchers are investigating the state of weightlessness, visual problems, physiological day-night cycling, and related factors.

Beyond the manned satellite we foresee the orbital space station—a kind of assembly area and operating base from which deep space ships will transport human passengers to the nearer planets when more efficient propulsion systems become available.

Technicians fuel a Nike guided missile at an antiaircraft site (Army photo).

LET us review briefly the military programs which have made possible our initial space ventures. The Army has for years been developing and fielding surface-to-surface and surface-to-air rockets and guided missiles to replace and supplement conventional artillery on the battlefield or to protect cities and strategic targets. The missile systems employed in spatial projects are the long-range ballistic weapons such as the Redstone and the Jupiter. The Air Force will employ a combination of its Thor and the Navy's Vanguard rocket in several lunar probes.

Redstone is the Army's biggest weapon. It is a mobile system which will soon be deployed with NATO Shield Forces. The first artillery group armed with the weapon is completing training at Huntsville preparatory to overseas movement.

The Air Force will operationally employ the Jupiter intermediate range ballistic missile which can strike targets 1,500 nautical miles from its launching site. An Air Force squadron to operate Jupiter is undergoing training at the Missile Agency and is scheduled for deployment this year.

THE fielding of Redstone is a major step forward in the military history of rocketry because it demonstrates convincingly that these huge, automated "beasts" can be tamed and integrated into our combat forces as useful tools. Redstone can transport either conventional or atomic warheads with more than adequate precision.

Because of its range of several hundred miles, ground commanders will operate more independently in their scheme of maneuver, supported by instantly available, massive firepower regardless of weather or terrain.

We do not consider Redstone the final word. Already a successor, the Pershing system, is in early development. This will be a lighter, even more mobile weapon capable of greater range. Rocketry moves so rapidly that no weapon can be considered perfect; at best, all are interim items which must be replaced as technological break-throughs enable us to provide more efficient weaponry. The toughest problem is to complete a weapons system before the advance of technology renders it obsolescent.

I should like to explain briefly the manner in which we divide the responsibilities for development and production of these systems in terms of expenditure of our available funds. Of the money available for the current orbital vehicle program, 82 per cent has been placed with industry for fabrication or purchase of components, 6 per cent will be spent in other Government agencies, and 12 per cent remains with us to cover the cost of development, some fabrication and procurement, assembly, testing, and launching.

IN fiscal year 1959 the space program will be divided 82 per cent to industry, 5 per cent to other Government agencies, and 13 per cent for internal operations in the Missile Agency.

In the ballistic missile program, where most of the dollars are spent, the fund distribution has followed this pattern:

Redstone System.—Industry has received or will receive 87 per cent of the total authority for fiscal years 1956, 1957, and 1958. Other Government agencies received 2 per cent and the Army Ballistic Missile Agency 11 per cent. Next year the industry portion will jump to 93 per cent because the missile has passed into the production stage.

Jupiter System.—Industrial contracts required 84 per cent of the total program in fiscal years 1956, 1957, and 1958, one per cent went to other Government agencies, and 15 per cent was retained by ABMA for research and development. Next year industry will receive 84 per cent, other Government agencies one per cent, and ABMA 15 per cent.

Pershing System.—This is in the initial development stage, and funding has been limited. Industry will receive 95 per cent this year, other Government agencies one per cent, and ABMA retains 4 per cent. Next year the allocation will be 93 per cent to industry, 2 per cent to other agencies, and 5 per cent to ABMA.

In this case the industrial share is larger because we have contracted on a system-responsibility basis in order to free our development team for new projects and in order to spread the influence and experience of our people more widely in the missile industry.

Our programs have direct impact in every state of the Union, either in industry, research, institutions, or other Government installations. During the next fiscal year the Army expects to invest nearly $2,000,000,000 in its rocket, missile, and space programs.

What do these programs contribute to national defense? Here I want to quote from the report of the President's Scientific Advisory Committee which said:

"There may well be important military applications for space vehicles which we cannot now foresee and developments in space technology which open up quite novel possibilities. The history of science and technology reminds us sharply of the limitations of our vision. Our road to future strength is the achievement of scientific insight and technical skill by vigorous participation in these new explorations. In this setting, our appropriate military strength will grow naturally and surely."

The rôle of the long-range ballistic missile is clearly understood. It is the vehicle by which warheads can be placed upon enemy targets over distances of thousands of miles, at velocities which almost defy interception or advance warning, and without exposure of highly trained crews.

The intermediate-range missiles, like Jupiter, operating with complete mobility from bases in friendly territory, can achieve much the same objective as the intercontinental missile, which can be launched from the security of our own country. So, too, will the Navy be able to strike with missiles from ships either on or below the surface.

The orbital vehicle, presently assigned scientific missions only, is well adapted to military requirements. Reconnaissance of the type mentioned earlier would deny to any power the advantage of secrecy in large-scale concentrations or movements anywhere.

Thus the surprise attack, on any but a relatively limited scale, would be much less of a threat than it is today. Underground launching or assembly sites might temporarily defeat the all-seeing eye in space, but it is highly doubtful that such advantage could be retained by an aggressor.

Weather forecasting based upon orbital observation will achieve unprecedented accuracy and reliability. The early detection of violent storms and the detailed charting of their movements will yield untold benefits. Since weather directly affects military operations, it can readily be understood that this type of reporting would have immense value.

The communications satellite, facilitating worldwide transmission of sound or video images, has both peaceful and military significance. Precision mapping has been aided by the Explorer so that the Army Map Service, using this known point in space as reference, can reduce map errors from miles to feet over distances of thousands of miles. For precise target spotting, precision of this order is invaluable.

IF successful, the lunar probe will afford data on an environment about which we know little beyond that available by astronomical observation. What can this mean to national defense? I suggest that international prestige in a time when psychological subversion has been employed to advantage by a potential enemy becomes very much a part of defense. The launchings of our satellites helped offset a serious propaganda success enjoyed by the Soviet Union. Explorations of the lunar region will contribute to world appreciation of the capabilities of this country's scientific-industrial military team.

Research for Defense

Program of the Association's Annual Industrial Preparedness Meeting

The Fortieth Annual Industrial Preparedness Meeting of the American Ordnance Association will be held on Wednesday, December 3, 1958, at the Waldorf-Astoria Hotel, New York City. There will be morning and afternoon seminars on military research, an Armament Preparedness Luncheon, and the annual Industrial Preparedness Dinner. A.O.A. Vice-President Louis Polk, President, the Sheffield Corporation, Dayton, Ohio, and Vice-President of Bendix Aviation Corporation, Detroit, Mich., will preside at the seminars. The program follows.

Morning Session — 9:30 o'clock — Starlight Roof

SEMINAR ON BASIC RESEARCH NEEDS OF THE MILITARY SERVICES

CHAIRMAN

DR. HUGH L. DRYDEN

Deputy Director, National Aëronautics and Space Administration
Washington, D. C.

THE ARMY NEED FOR FUNDAMENTAL RESEARCH

MAJ. GEN. AUGUST SCHOMBURG

Deputy Chief of Ordnance, United States Army
Washington, D. C.

THE NAVY NEED FOR FUNDAMENTAL RESEARCH

REAR ADM. JOHN T. HAYWARD

Assistant Chief of Naval Operations for Research and Development
Washington, D. C.

THE AIR FORCE NEED FOR FUNDAMENTAL RESEARCH

MAJ. GEN. LEIGHTON I. DAVIS

Deputy Commander for Research and Development
Air Research and Development Command
Washington, D. C.

Midday Session — 12:30 o'clock — Starlight Roof

ARMAMENT PREPAREDNESS LUNCHEON

PRESIDING

LIEUT. GEN. LESLIE R. GROVES

President, New York Post, American Ordnance Association; Vice-President, Remington Rand Division, Sperry Rand Corporation, Bridgeport, Conn.

ADDRESS

LOS ALAMOS—A RESEARCH LABORATORY AT WORK

DR. NORRIS E. BRADBURY

Director, Los Alamos Scientific Laboratory, N. Mex.

Afternoon Session — 2:45 o'clock — Starlight Roof

SEMINAR ON FUNDAMENTAL RESEARCH POTENTIAL FOR AMERICAN ARMAMENT

CHAIRMAN

DR. LLOYD V. BERKNER
President, Association of Universities, New York, N. Y.

ADVANCED DEFENSE RESEARCH

DR. HERBERT F. YORK
Chief Scientist, Advanced Research Projects Agency
Department of Defense, Washington, D. C.

INDUSTRY'S DEPENDENCE ON DEFENSE-SUPPORTED FUNDAMENTAL RESEARCH

DR. LOUIS N. RIDENOUR
Director of Research, Missile Systems Division, Lockheed Aircraft Corporation
Sunnyvale, Calif.

CONVERTING THE OUTPUT OF FUNDAMENTAL RESEARCH TO PRACTICE

DR. ALEXANDER H. FLAX
Vice-President—Technical, Cornell Aeronautical Laboratory, Inc.
Buffalo, N. Y.

Evening Session — 7:00 o'clock — Grand Ballroom

INDUSTRIAL PREPAREDNESS DINNER

PRESIDING

LIEUT. GEN. LESLIE R. GROVES
President, New York Post, American Ordnance Association; Vice-President, Remington Rand Division, Sperry Rand Corporation, Bridgeport, Conn.

TOASTMASTER

GEN. BENJAMIN W. CHIDLAW
President, American Ordnance Association
Vice-President, Thompson Products, Inc., Cleveland, Ohio

AWARD OF THE WILLIAMS GOLD MEDAL TO

VICE ADM. JOHN H. SIDES, U. S. NAVY
Director, Weapons Systems Evaluation Group
Department of Defense

ADDRESS

VICE ADMIRAL SIDES

(Reservations close on Monday, November 17, 1958)

Recent Aircraft Developments

The Chance Vought F8U-3 Crusader III, above, is the Navy's all-weather Mach 2 jet fighter armed with Sparrow III guided missiles and equipped with afterburner (Air Force photo).

The Navy's new North American A3J-1 Vigilante carrier-based twin-jet Mach 2 attack bomber ejects its bombs rearward from a tunnellike bomb bay, solving airflow problems (Navy photo).

North American's Sabreliner is a new twin-jet utility trainer and transport designed to allow Air Force pilots to maintain combat flying proficiency at reduced operating cost.

The Northrop T-38 advanced Air Force trainer is a 2-place supersonic aircraft combining light weight, high performance, and ease of maintenance with low cost (Air Force photo).

An Air Force F-100D is shown above completing the first successful zero-length launch of a supersonic jet—a development that will make these swift craft independent of runways.

The twin-jet Douglas A3D-2P Navy photo reconnaissance aircraft can take continuous film footage for several hours, day or night, at high or low altitudes. Side bulges house camera equipment.

War, Peace, and Space

General Gavin's recent book reveals his belief that nuclear power, while possibly able to deter all-out war, cannot prevent the outbreak of limited conflicts nor help us achieve victory if we become involved

Hoffman Nickerson

LIEUT. GEN. James M. Gavin's recent book, "War and Peace in the Space Age," (New York: Harper & Brothers) is a blistering attack upon much of U. S. military policy, and the present writer hopes that it will have a great effect.

With a personal authority not granted to many analysts of war, General Gavin has voiced the doubts and fears of not a few others who have been troubled by what we as a nation have been doing. At fifty years old with a third of a century of distinguished Army service behind him, his practical, technical, and theoretical competence cannot be denied.

An orphan, he enlisted in the Regulars at seventeen, gained an appointment to West Point, and has continually studied his profession. He jumped with the paratroopers on Sicily, again at Salerno, and once again in Holland.

After acting as Chief of Research and Development for the Army, he recently resigned from the service which he loves, from which he has received so much and to which he has given much more, deliberately turning his back on a brilliant military career which might have ended by raising him to the highest honors which the armed services can give.

A dedicated man, he has done this in order to speak freely to us, his fellow citizens, and we will do well to listen.

Readers of ORDNANCE are familiar with the policies with which the author disagrees. After 1945 we separated our Air Force from the Army, and in the name of unity we superimposed a Defense Department upon the three armed services.

Mr. Nickerson is a well-known American military historian and author of several books including "Can We Limit War?" and "The Armed Horde, 1773-1939." He is a frequent contributor to ORDNANCE, *his most recent article, "Limited War, 1957," having appeared in the November-December 1957 issue.*

When the aggressiveness and increased power of world Communism—for which our own unwise conduct during World War II was largely responsible—had become too obvious to be ignored, we persisted in hoping that manned bombers equipped with nuclear bombs and teamed up with a shrunken Army would be a sufficient answer to any military threat. But the Communists resurrected limited war, and we consented to a stalemate in Korea. They also gained a limited but real success in Indo-China.

The Soviets, too, have learned how to make nuclear bombs. As the face of future wars continues to change, thanks to the rush of new applications of physical science, we go on cutting down the size of our Army, and at the same time we struggle with steadily rising military costs.

What are General Gavin's prescriptions? He notes, of course, that today the concept of limited war "is only valid within an impressive . . . capability to wage general war." In other words, our ability to wage all-out nuclear war is our only reason for believing that a powerful opponent may well be content to keep the war limited.

He demolishes the often-repeated falsehood that today the power to wage total war necessarily implies the power to win limited wars:

"LIMITED war . . . is a highly specialized form of combat . . . It is as though one were to compare skillful surgery to a killing blow. The first requires special instruments applied with restraint . . . and accurately; the latter a bludgeon with only one object, complete destruction. To assume that SAC can deal effectively with every type of limited action is the same as to assume that since a tank battalion can be used to control extensive land areas, one tank can be used to catch a pickpocket or car thief."

Yet if we can't fight and win limited wars we can't survive, "for that is the kind of a war we will be confronted with."

Speaking of tanks, his reasons for preferring J. F. C. Fuller's writings to those of the other analysts of armored

Strategic bombers armed with nuclear weapons may be able to prevent the outbreak of all-out wars (Air Force photo).

warfare—Chaffee, DeGaulle, and Guderian—show the clarity of the author's mind. Fuller "saw it with all of the attendant problems of communication, command, and decision . . . He had fitted it into the pattern of history . . . far more important than 'what' was happening was 'why' it was happening."

On the other hand, General Gavin's appreciation of both practical experience and historical analysis has by no means led him into ultraconservative military thinking. On the contrary, his scientific bent and his close contact with scientists have encouraged him to generalize boldly on various matters which are so specialized that only a handful of experts can begin to have an informed opinion concerning them.

THUS he believes that surface-to-air missiles are already so efficient and are improving so rapidly that in the near future the manned bomber will be helpless before them. Consequently its function of "strategic," *i. e.*, long-range, bombing will be taken over by long-range missiles. Those who remember the opposing arguments set forth by Gen. Curtis E. LeMay in the September-October 1958 issue of ORDNANCE will long to witness a debate between the two generals, each supported by a war-strength platoon of scientists!

Further, General Gavin makes the point that the smaller missiles, since they need no heavy gun carriages, are lighter and therefore more mobile than artillery pieces. Their lightness makes them especially suitable for airborne warfare, and the author again agrees with Fuller that airborne mobility will play a great part in future conflicts.

This leads him into a discussion of helicopters and airplanes which might be able to take off and land vertically. He several times speaks of "sky cavalry," and it would have been interesting if he had offered a tentative sketch of what might be suitable organization and equipment for a "sky cavalry" division or corps.

He notes that an "immediate consequence of our failure to understand the lessons of World War II was the separation of our Air Force and land force at the very time that they should have been becoming more closely associated. Only the Marine Corps retained an integrated land-air team. The Army and Air Force separation proved . . . costly . . . in Korea."

OUR city-busting bombs would have been of little value in Indo-China because the crews of our big bombing planes could not have used them without killing French as well as Communist troops. Similarly, if the Red Army occupies Western Europe will we destroy West European cities?

The author attributes our unwise military decisions chiefly to three causes. The first of these is the Air Force's obsession with long-range bombing in the teeth of continually improving air and ground defense against such bombing. He brings out into the open what various other military writers had already learned to their sorrow—*i. e.*, that the Air Force has had some success in stifling discussion of their pet theories by officers on the active list.

IN 1948, when he wrote an article arguing that in future wars air transportation would be as important as or perhaps more important than bombers and submitted it to the Department of Defense for clearance, it was returned with "a nonconcurrence in its publication and a number of specific items to which the Air Force objects."

And yet among the "objectionable" items were quotations from the U. S. Strategic Bombing Report on World War II which the Air Force itself had organized and sponsored. That a man of General Gavin's caliber should be silenced in this way is a national scandal.

The second cause to which he attributes our errors in military policy is the personality of President Eisenhower's first Secretary of Defense, Charles E. Wilson. The book quotes with approval a statement attributed to

a Chief of Staff other than General Ridgway that Wilson was "the most uninformed man, and the most determined to remain so, that has ever been Secretary."

GENERAL Gavin's third cause for faulty and for unnecessarily delayed decisions is a reversal of Lloyd George's famous saying that "war is too important to be left to the generals." According to the author, our trouble is just the opposite.

In the armed services the excellent civilian-military relationships of World War II have been dislocated. The law which forbids our officers, many of them dedicated men who have, as it were, taken vows of poverty and obedience when they might have been earning much larger salaries in civil life, to be executives or decision makers in the Defense Department prevents their adequately advising their civilian superiors.

In that Department they can only be aides and assistants. Consequently the civilian chiefs have formed the habit of going for advice chiefly to permanent civil service employees.

These three causes have combined to produce the bickerings and postponements which have hindered our missile program, have absurdly restricted the range of the Army's missiles, and have slowed down our efforts to launch an earth satellite. We have already noted General Gavin's high estimate of the value of missiles in the near future. He also tells us that the U.S.S.R.'s success in launching the first satellite is "the most significant military event of our time" because it promises soon to lead to manned space flight with its many military applications in reconnaissance, mapping, and general employment of missiles.

It is a very serious thing to be told by such an authority that there may indeed be a "missile lag" of several years in the near future during which we definitely may be inferior to the Soviets. Newspaper readers have learned of such a lag in the lively columns of the Alsops, but the Alsops have publicly beaten their breasts so often that the effect of their warnings is wearing off—like that of the proverbial little boy who cried "Wolf!" General Gavin's testimony is of a very different sort.

On one capital point, however, General Gavin may not have fully clarified his thinking. He tersely repudiates Khrushchev's prediction that in the U. S. our "grandsons will be Socialists." Socialism in any form—and Communism is only its complete and logical form—is indeed the opposite of traditional Americanism.

BUT a few pages later he approvingly quotes Max Lerner's saying that America is losing its "social and moral vigor" because of "the fear of ideas and the tenacious cult of property." Surely, unless one believes in the moral right of property one ought to be a Socialist.

The contradiction is pointed up by his persuasive advocacy of greatly increased military expenditures. In addition to our military costs, we are half socialized already by the confiscatory taxation which supports our welfare programs and the masses of Government employees who administer them.

If, without cutting our welfare projects, we go on increasing the cost of preparing for war—and the present writer is not saying that military appropriations should be held down—what is to keep our confiscatory corporation tax, income tax and inheritance tax from socializing us still more?

Trained men and equipment on the ground are needed to contain and extinguish "brush-fire" conflicts (Air Force photo).

Machine Gun Muddles

From its very beginning the machine gun has been subject to many tactical misconceptions and technical contradictions that often have lessened the very great defense possibilities of this weapon

Lieut. Col. Melvin M. Johnson, Jr.

SOME five centuries ago crackpots considered machine (revolver) muskets, various forms of multiple-barrel and sequential-fire slug-slingers. The fantastic Leonardo da Vinci, of course, concocted some machine-gun ideas—which in the confines of his times he could not exploit.

About 1718 Englishman James Puckle invented a more modern revolver gun, operated by a crank (no reflection on inventors). A devout Christian, Puckle proposed square projectiles for Turks, round for Christians.

The outstanding mid-nineteenth century hand-cranked machine gun was developed by Dr. Richard Jordan Gatling. From his time on, the machine-gun muddle was magnified by a variety of tactical misconceptions and technical hangovers, no less prevalent now than in the past hundred years.

The main mission of a machine gun is to dish out doses of bullets at brief intervals—realistically to fire one-second bursts of from six to twenty-four slugs.

Much machine-gun muddling arises from the "shots per minute" fallacy. For example, the U. S. water-cooled Browning machine gun, belt-fed, tripod-mounted, weighing 41 pounds plus a 53-pound tripod, fires 500 to 550 shots a minute. The recently adopted 9-pound U. S. M14 automatic rifle fires 750 shots a minute. Does this mean that the 9-pound auto-rifle is more powerful than 94 pounds of water-cooled Browning?

Colonel Johnson, U.S.A.R., Inactive, is the inventor of the Johnson semiautomatic rifle, Johnson machine gun, and other arms. He is currently a research consultant and technical adviser for government contractors and industries.

Facts: the Browning can actually deliver hundreds of shots at its rate—more than a thousand rounds in two elapsed minutes. The 9-pound auto-rifle, and there are lots like the new M14-M15, can fire only twenty shots in one burst. The 20-shot magazine must be changed—a matter of some seconds.

In one minute the auto-rifle could fire only 200 to 300 rounds. If it fired continuously at this speed, less than 500 shots would burn it out. Even the most recent powders and best barrel steel do not put air-cooled magazine-fed automatic rifles into the venerable water-cooled machine-gun class for hour-long fire.

But there are more muddles and machine-gun misconceptions. Under what tactical circumstances, in what kind of fighting, would any machine gun be squirted continuously like a hose for more than a few seconds? Would the targets just park there?

On some classic occasions machine guns have engaged mass targets. In many other instances the potential of the machine gun against mass targets went unexploited, again due to tactical muddles and misconceptions. For the future, as in the more recent past, mobility in the machine gun must take increasing precedence over prolonged slug-slinging.

The Gatling hand-operated machine gun, a most powerful and defensive arm, was "demonstrated" for the North against the South at Gettysburg, but its murderous mass fire of up to 1,000 slugs a minute was not even appreciated some years later.

GENERAL Custer refused to include Gatling guns on his tragic expedition against Sitting Bull which resulted in the 7th Cavalry massacre. It is quite conceivable that Gatling guns could have saved Custer at the Little Big Horn, but the Gatling was too heavy and clumsy for the dashing Custer cavalry concept of mobility. So he engaged Sioux repeating rifles with single-shot carbines.

Despite the origination of the Gatling, the Maxim, the Browning-Colt, the Hotchkiss, Benét, the Browning M1917, and other guns by American inventors, the Germans in World War I were first to exploit mass-fire machine-gun tactics. In 1917 the Germans had over 50,000 Maxim machine guns in service, the U. S. only some 400 guns

of 4 different types. Hence in desperation the French Hotchkiss machine gun was borrowed for the American Expeditionary Force, illustrating another muddle of no mean proportion.

As in 1914, the Germans led again in 1939 by organizing their 26-pound air-cooled MG34 machine gun into their infantry *gruppe* or squad of thirteen. This system put the machine gun where it could give the most immediate delivery of pay-off burst fire, which the Nazis needed because they did not then issue semiautomatic or automatic rifles.

Because of its weight with tripod mount, the machine gun impaired infantry mobility. A technical response to this tactical need was developed: *light* machine guns and automatic rifles.

BOTH heavy and light machine guns give bullet bursts forming a "cone" of fire several feet high, a few feet wide, and hundreds of yards long. At extreme ranges, the cone becomes comparatively very short because the bullets are descending at more of an angle.

The heavy machine gun gives a much closer pattern than a light automatic because of the difference in weight and support. In consequence, machine guns are generally inefficient against spread-out targets to their direct front yet murderous when fired against the flank of an extended line.

Many muddles have resulted from persistent misunderstanding of what targets were unprofitable for machine guns, and what not to do against them.

Stability has been a persistent problem, a source of major muddle in machine-gun fire from heavy-tripod to light-bipod machine guns, automatic rifles, and submachine guns. Addicts to geometric charts can draw most lucid lines to illustrate the pattern.

First there is the heavy caliber .30 type machine gun weighing some thirty to forty pounds and requiring a tripod or vehicle support. For such anchored weapons, stability depends less upon the cyclic rate, whether five, ten, or twenty shots a second.

Secondly, there are 20- to 30-pound automatics mounted on bipods, butt on the shoulder, which depend upon reduced cyclic rates, preferably below six shots a second.

Thirdly, light (9- to 12-pound) automatics, fired from bipod or standing, depend even more upon reduced cyclic rate but especially upon reduced powder power and smaller, short-range ammunition.

Fourthly, so-called submachine guns fired from shoulder or hip depend upon a measure of gun mass (weight of up to ten pounds), reduced cartridge power (pistol ammunition), and slow cyclic rate (below ten shots a second).

Stability of the very highest order would be achieved by combining the following characteristics: A tripod of fifty pounds with a submachine gun of ten pounds having a cyclic rate of under seven shots a second using a cartridge of low pistol power. How muddled can we be?

Least stable in fire would be: a light automatic rifle of 6 or 7 pounds with shoulder-hip support, having a cyclic rate of fifteen shots a second using a high-power cartridge.

Mobility seems essential for any future firearms, especially machine guns or their equivalent. Current publicity discloses a new U. S. M60 general-purpose belt-fed air-cooled machine gun weighing twenty-three pounds with bipod and about forty pounds on tripod.

The Russians have announced a new 15-pound belt-fed machine gun which probably weighs around thirty pounds with tripod. Both weapons have cyclic rates of 10 to 12 shots a second, necessary for basic operating power and belt pull.

THE U. S. has actively sought a light belt-fed machine gun of some twenty pounds over the past quarter century. Interim guns during that period were the Browning M1919A4 and A6,

Trained crew fires air-cooled cal. .30 machine gun from roadside during Korean fighting (Army photo).

Old Infantry small-arms system: back (l. to r.) BAR, submachine gun, carbine, and M1 rifle; front, heavy cal. .30 gun and two light machine guns (Army photo).

weighing about forty-six pounds with tripod, and the 20-shot magazine-fed Browning automatic rifle M1918A2 weighing about twenty pounds.

In a sense, such 1957 types as the U. S. M15 and Belgian-British FN magazine-fed weapons are semiautomatic rifles with the full-automatic "machine gun" burst feature—twenty shots in less than two seconds if you hold down the trigger for one magazine load.

But—that inevitable gun "but"—such light full-automatic "machine guns" are much less stable than heavy tripod-mounted types. Their dispersion—spread of shots—is bad enough from the bipod, far worse from shoulder support alone. This is the drawback despite varieties of compensators and other means to reduce kick and uncontrolled spatter.

Here we have the most mammoth machine gun muddle of all. This has for one thing brought about resort to pistol ammunition because of its low kick and dispersion—with much less range and power.

MUCH of this machine-gun muddle could have been and may yet be overcome by a most obvious solution, so far curtailed by concepts. A characteristic objection to this remedy has been to insist that the trigger finger would get too tired!

Mobility married to machine-gun fire is achieved, nevertheless, by *fast semiautomatic fire,* two to four shots a second by simple trigger pulling. This is not the way to shoot machine guns—it is the way to get hits!

So there is a muddle of high order. Demands for mobility have meandered in this maze of misconception for half a century. Pause and consider a water-cooled Browning on tripod at some ninety pounds versus one or more shoulder rifles with bipod at ten pounds apiece.

This writer and others have individually aim-fired 10- to 12-pound 20-shot magazine-fed bipod shoulder weapons on semiautomatic for as much as 30 minutes at 50 shots per minute delivered, 1,500 rounds in half an hour. The trigger finger was less tired than a man's back would have been if he had carried 1,500 rounds, which would weigh around 100 pounds.

THIS writer and others have fired 20 aimed shots in 12-15 seconds with 15- to 20-inch bull groups at 200 yards. It is quite possible to fire 5- to 6-foot rectangular patterns 80 to 100 shots in one minute at 600 yards. Semiautomatic "burst" fire can produce at least sixty shots in one minute, and from two to three per second in short strings of several seconds.

Effective heavy machine gun fire gives no more than 60 to 120 shots a minute. Bursts of five to ten shots are fired, then the gun is re-layed as new targets or areas are sought and searched. Areas where unseen targets are believed located remain principal objectives for the heavy machine gun.

Certainly for direct hypermobile fire at targets seen from the gun, two semiautomatic weapons on bipods can compete with one tripod-mounted machine gun. The semiautomatic weapons can deliver as many effective shots in aimed bursts. They are much more mobile and concealable. Two such weapons need weigh no more than a new U. S. M60 machine gun with bipod or a German MG42. Add tripod weight and you can have nearly *four* of the semiautomatics for one complete air-

Final version of the new M60 light machine gun on tripod mount (Army photo).

cooled machine gun—eight versus the 94-pound water-cooled Browning (41 pounds) on tripod (53 pounds).

Special powders and liners are giving much more life to light machine gun barrels. The Army has published reports of some 20,000 shots being fired from an M60 air-cooled barrel. The venerable Browning and Maxim water-cooled guns were great when you had plenty of water, no one punched holes in the water jacket, and you had not far to walk!

About ten years ago the writer took part in extended efficiency tests of a water-cooled machine gun on tripod, a 20-pound light machine gun on bipod, and a 12-pound semiautomatic gun on bipod. Against a wide variety of targets up to 800 yards, the semiautomatic type approached the heavy gun, beat it on some, and quite outclassed the light machine gun's full-automatic fire.

THE semiautomatic "chopper" was of course much quicker to "deliver its goods" and shove off. It was much more easily and quickly hidden, less exposed in action. It required less shots per direct hit and was more on the beam in its area-fire coverage. Virtually untrained men delivered bursts of ten shots in some three seconds even from unsupported positions.

The venerable M1918 U. S. Browning automatic rifle started out with full and semiautomatic fire control. For many years most of its fire was on semiautomatic as with the Marines in Nicaragua (1927). When you pulled the trigger the open breechblock closed, "kerplunk"—not so good for accuracy.

About 1938 the Army adopted a slow-rate device, adding some two pounds and a bipod of over two pounds. The rate reducer gave the 20-pound BAR "A2" a cyclic rate of 350 per minute plus the basic 550-600 fast rate. But no more semiautomatic!

The writer's 12-pound M1941 Johnson "light machine gun" and the later light German FG44 gave features of full automatic from an open bolt like the BAR, but semiautomatic from a closed bolt like the M1 Garand semiautomatic rifle. Inevitably some attempts were made to modify the BAR "A2" back to semiautomatic, but this proved impractical in the basic BAR design.

Vintage 1958 light automatic rifles—such as the Garand-modified U. S. M14-15, U. S.-developed Fairchild AR-10, and the European Fabrique Nationale (FN)—all fire both semiautomatic and automatic from a closed bolt, a major advantage in semiautomatic accuracy. The U. S. M15 includes a heavier barrel with a bipod on the theory that this added weight will give air-cooled machine-gun endurance and stability in "machine-gun" fire.

SO the machine gun muddles on, seeking to combine all the ancient elements of automatic burst, half-hour barrage, 90-pound stability, mile-long range, 3-mil dispersion at 500 yards—all this and more in a featherweight firearm.

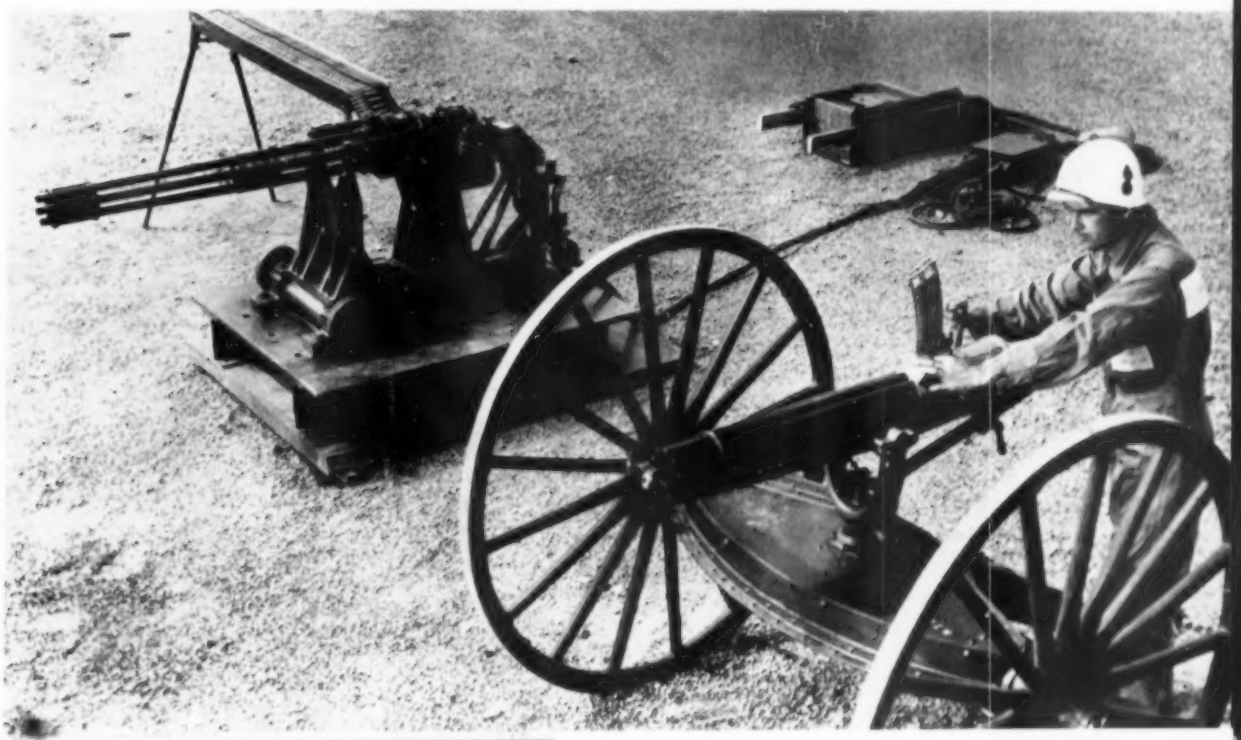
The various modified automatic arms are invariably conceived as substitutes for *the* machine gun: "general-purpose" machine guns, "light" machine guns, machine rifles, machine carbines, automatic rifles, submachine guns.

The squad weapon for the future is *not* going to be the machine gun! Call it for the sake of convenience a "semiautomatic gun." Toughen the tender trigger finger. Reduce the load on the soldier's back and on the helicopter. Boost the amount of shots you can fire without taking time to reload. Use the bipod where you can.

Take adequate time training! Try the valuable 2-man "buddy" team technique. Have plenty of ammunition, grenades, and a holster-stock pistol for the assistant gunner.

Get the "mostest" hits with the "leastest" lead. No more machine gun muddles!

New Vulcan 20-mm. aircraft cannon, left, is direct decendant of the hand-cranked Civil War Gatling gun (Army photo).



LACROSSE IN ACTION

The Army's field-artillery surface-to-surface guided missile can deliver numerous types of warheads with great accuracy due to control by a forward guidance station. The missile, its launcher, and the guidance system are mounted on mobile carriers, allowing the weapon to go into action or relocate quickly. It will replace heavy artillery in strikes against strong points delaying the advance of ground troops.

The missile body is composed of three sections. Four swept wings and four tail fins snap into slots in the body. Over-all length is 19.2 feet, fuselage diameter is 20.5 inches, and wing span is 9 feet. Lacrosse is manufactured by the Martin Company and is powered by a solid-propellant rocket developed by Thiokol Chemical Corporation.

The Lacrosse weapon system was developed out of World War II experience in the Pacific campaigns when U. S. troops had great difficulty in destroying fortified caves and bunkers. The Lacrosse, with its one-shot accuracy, is an effective answer to this problem.

The Lacrosse warhead, above, is being hoisted into place by a mobile crane to be affixed to the missile on its truck-mounted launcher.

After the warhead is attached, the four wings are installed, as shown above, then the tail fins are snapped into place, below. The fins are movable and control pitch, yaw, and roll.

When the missile is assembled, it is moved to the launching site and tested. Technician, above, uses antenna test tool while circuits are checked, below.

After assembly and preliminary test, the missile is elevated and the firing cable is attached as shown above. This cable will pull off as the Lacrosse leaves its launcher when fired.

Missileman at left, above, checks firing cable while technician at right uses automatic circuit tester mounted on truck. Below, the missile is bore-sighted in preparation for flight.

Fire! Using a solid-propellant rocket motor, Lacrosse heads toward its target directed by a mobile forward guidance station, resulting in accuracy of a high order.

Security with Solvency

It can be achieved by selectively acquiring only those military capabilities best calculated to support a plan of national defense based on conventional forces backed by retaliatory atomic potential

Capt. Richard H. Bowers, U.S.N.

SINCE the Korean war, abundance of monies and a burgeoning technology have conspired against us. Unhampered by interservice priorities among broad military capabilities, stimulated by spectacular refinement in nuclear devices, and equipped with ample funds, the major factions of the several services have been able to pursue individual concepts of defense requirements.

The outgrowth of having followed all avenues at once is an amorphous profusion of weapon systems in being and under development which results in ambiguity in our defense structure. Such ambiguity, in combination with a national frame of mind infatuated with the atom and disinclined toward selectivity in the accumulation of armed might, has nurtured the following paradoxical rationalization:

"An all-out atomic war would result in world devastation within a matter of days. Therefore, it is imperative that we arm ourselves to the teeth with atomic weapons, incorporating the largest practicable yield into all possible weapon systems —land, sea, air, undersea—and stockpiling each just as fast and as numerously as we can, without regard to cost nor to which ones could be usefully brought to bear upon the enemy in an engagement lasting only a few days.

"Fortuitously, such universal application will not go for naught, even if all-out atomic war is forestalled, in that employment of nuclear arms will greatly shorten and facilitate a tactical war or a war of attrition, thereby making it far less costly in men and materials; provided, of course, the world is not devastated in the process.

"As to this last, however, it is to be expected that an intelligent enemy will perceive the advantage of losing a war more cheaply than heretofore and hence will submit to his own devastation by degrees rather than resorting to all-out atomic warfare to heap devastation upon us in return."

Just prior to Sputnik I, it was becoming evident that the fabulous expense of supporting this paradox was catching up to us and stressing the defense budget to a point where over-all balance of military capabilities was beginning to suffer—unglamorous conventional weaponry was being squeezed out.

Now, as we embark upon the satellite era, we have decided that defense expenditures must be increased, but there are no indications that this portends any relief in balance.

Augmentations appear to be destined for heightened emphasis upon long-range missilery, leaving conventional armament still in uneven competition with so-called tactical nuclear weapons within essentially the same uncoördinated fiscal base as before.

The demonstrable evidence that the Communists have added unexpected superweapon potential to their existing conventional power exhorts not jumping to hasty conclusions but rather a comprehensive evaluation of our entire military posture. The fate of the world hangs upon our achieving full rather than fragmentary military security.

IMPLICIT in complete security, however, is our remaining solvent the while; security with solvency—a balanced arsenal within our means.

It is clear that the keystone to this happy state lies in a closely reasoned national estimate of the world situation to supplant an uneasy compromise among multiple factional estimates. As a point of departure in essaying such an estimate, and as a reference beacon throughout the analysis, definition of the opposing missions is fundamental.

The mission of the United States could be stated quite simply as being to stem the tide of Red politicomilitary domination without ever precipitating thermonuclear warfare. The timelessness of the phrase, "without *ever* precipitating thermonuclear warfare," cannot be overemphasized.

Captain Bowers is currently serving in the Plans and Programs Division of the Special Projects Office, Bureau of Ordnance, United States Navy, Washington, D. C.

Equally simply, the mission of the Communists can be postulated as being to secure world politicomilitary domination in order to aggrandize and assure the prosperity of the Reds.

The possibility uppermost in our minds is the surprise thermonuclear onslaught against the continental United States. Presupposing our forbearance against initiation of hostilities, the only course of action open to us for countering this potentiality is to maintain the ability to react instantly with such massive and punishing retaliation as to make the exchange unprofitable to the aggressors in the furtherance of their mission.

A prostrate homeland will contribute nothing to Red prosperity. We therefore surmise that the basis for the requisite magnitude of our retaliatory threat is the degree of devastation to their homeland we adjudge to be unacceptable to the Russians, vis-a-vis their capacity to mitigate the blow through the force of their initial attack and their ability to defend against our retaliation.

OUR goal, therefore, is to acquire sufficient might, plus ability to protect that might, that we could sustain an initial surprise attack and still counterpunch quickly through ready enemy defenses with havoc more extensive than he can tolerate.

The judgment of "sufficient offensive might" should be an enlightened appraisal of what we need to accomplish our purpose and not a mere mechanical matching of Red offensive prowess stick by stick and not a redundant capacity to do the job many times over. Once we have achieved this goal, it is our total defense against Russian intent of a suprise thermonuclear onslaught.

What if they do miscalculate or give way to an impulse—what then? The exchange could result either in the world devastation predicted by some or in a state of debilitation something short of permanent paralysis. Dismissing the former as a contingency for the next civilization to cope with, let us speculate upon the situation in the latter case. It is to be presumed that a large portion of worthwhile thermonuclear targets on each side will have been destroyed, defense preparations to the contrary notwithstanding. The bulk of the opposing bomber fleets will have been decimated, stocks of intercontinental missiles depleted, and the means for logistic support of other forces demolished. In a word, the war-making potential of the protagonists will have been reduced to virtually nil, temporarily at least.

Under these circumstances, there appear to be two possibilities. First, one or both sides might acknowledge a stalemate and negotiate a truce. Or, secondly, from amidst the rubble the adversaries may collect their wits and grimly proceed to rejuvenate warmaking machines.

There might then ensue, beginning perhaps weeks, perhaps years, after the holocaust, a lengthy war of attrition in which nuclear weapons would be used sporadically, according to the availability of fissionable material and the emergence of worthy new targets.

Commensurate with the probability of an all-out exchange, then, we require as *secondary* defense a basic capability for the refined execution of protracted thermonuclear war.

Having dealt with the contingency of a thermonuclear onslaught which shatters the peace without preliminaries, we proceed to study possible alternative Communist courses of action. It is of consummate importance from this point onward in our analysis that we never lose sight of the qualifying phrase in our mission, "without *ever* precipitating thermonuclear warfare," and that we probe each contingency from the point of view of the likelihood of its eventual eruption into the thermonuclear action.

To begin with, we may make the general observation that if the Reds elect hostilities other than an attempt to eliminate the U. S. in one fell swoop, they do so in hopes of making profitable consolidation of territory, productive in one way or another, without inciting us to thermonuclear response. This clearly implies ultimate occupation of a relatively unscathed region with conventional field forces.

To checkmate Russian intent of a thrust at Europe, opposing courses of action open to us are: (1) To maintain sufficient collective allied conventional strength on the European Continent as to yield a good chance of thwarting a conventional attack or, (2) To place full reliance upon tactical nuclear weapons and reduce conventional forces accordingly. The former, obviously, would constitute a tangible damper upon Russian hopes for an expeditious victory. But what about the latter course? Were we concerned here with the military purist's narrow technical problem of executing a campaign completely isolated in time-space, the niceties of tactical nuclear weapons would be compelling. Yet how do they serve us as protection against Russian intent?

AWE of the enormity of thermonuclear warfare almost certainly means that in the absence of the direst peril to North America, a final irrevocable decision on our part to execute atomic action will not come easily. In the climate of universal dread, it is virtually impossible in advance of hostilities to disenchant our enemies of the difficulty we will have with that decision, except *in extremis*.

This means that dropping our conventional guard is tempting fate by proffering a continuing enticement for irresponsible, impulsive action.

Now let us speculate upon the ramifications of actual execution of general war with nuclear arms. The military purist, as we have said, sees atomic weapons as technically ideal tools for conducting campaigns. It is not enough, however, to consider the maneuver phase of military action as an end unto itself, with neither side enjoying any marked advantage.

Our analysis must be more subtle, more perceptive, and embrace the psychological effect upon a nation sensing either victory or defeat in war. We must ask ourselves with the most searching candor whether it really is reasonable to presume that use of nuclear weapons, once initiated, can remain restricted by tacit agreement to the tactical variety.

Once the battle is joined, with blood running high on both sides—once the moral threshold of abhorrence of atomic war is mounted and passed—is it realistic to predict that neither side will ever succumb to the temptation of a surprise thermonuclear punch, either in last-ditch desperation or upon being presented a seemingly favorable opportunity for scoring a *coup de grâce?*

If we are genuinely honest with ourselves, we must conclude that we cannot undertake any action with nuclear weapons of any size unless we are fully prepared to accept ultimate all-out thermonuclear war as a probable consequence.

The possibility, of itself, amply justifies rejecting reliance upon nuclear arms for defense against Russian intent of occupying Europe as long as an acceptable alternative exists. Building up and maintaining conventional strength *is* an acceptable and a reasonable alternative, if we but accord it the importance it is due, namely; its being second only to our thermonuclear retaliatory power as a timeless preventive against thermonuclear war.

We can theorize and rationalize endlessly on the prospect of the use of atomic weapons remaining controlled by tacit agreement, but common sense demands that we avoid putting this to the test in the heat of battle.

Before continuing, it will be prudent to examine general war with conventional forces in more detail. Through World War II, general war had been faithful to the classic definition which, paraphrased freely, characterized it as the attempt to gain national ends through recourse to unlimited force.

AFTER reflection, it does not appear that such a definition is any longer consistent with conditions as they are today nor with that part of our mission dedicated to prevention of thermonuclear war for all time. Although the threshold of abhorrence of atomic war stands as a psychological barrier against extension of conventional war into a thermonuclear exchange, even undue conventional force can push the vanquished too far.

What major power would not inevitably resort to thermonuclear weapons (the modern version of unlimited force) *in extremis,* unmindful of implications, in order to avert destruction and dismemberment such as Germany suffered as a result of World War II? None, of course.

This means that in our era, if general war with conventional forces is to remain conventional, the principle of unconditional surrender no longer can be invoked.

Let us consider now the final course of action open to the Soviets—that which frequently has been labeled "limited" warfare. In the light of the foregoing discussion, "localized" warfare seems a more apt term. It is defined herein as military action entailing only a fraction of the total resources of the combatants in pursuit of an immediate objective of politico-military domination of a single state or confined geographical region.

As in the assessment of general war, it seems incontrovertible that Russia would have little to gain and much to lose by electing to use atomic weapons as long as we possess a modest nuclear capability.

In localized war, even more than in general war, reliance upon tactical nuclear weapons on our part would be an inferior defense against Russian intent, because, as the immediate issues become smaller, our decision as to how much provocation warrants nuclear response becomes more difficult.

Once the atom is introduced, the temptation surreptitiously to exceed any tacit yield limit is great. Moreover, the likelihood of provocation by one side or the other through irresponsible or erroneous attack outside of tacit target limits is high. We are forced to reaffirm our principle that the best chance of avoiding thermonuclear warfare other than a surprise onslaught lies in avoiding any military action with atomic weapons of *any* size.

In summary, the major conclusions stated or implied in the foregoing analysis are as follows:

1. Our best protection against a surprise thermonuclear onslaught is sufficient retaliatory might, and defense thereof, so that we could sustain the blow and still deliver a swift counterpunch through Russian defenses of such proportions as to be unacceptable to them.

2. Our best protection against the eruption of other types of military action into all-out thermonuclear war is sufficient conventional strength to offer a good chance of thwarting a conventional invasion of Europe and highly mobile conventional amphibious striking forces to quell localized action.

3. The rôle of tactical nuclear weapons in preventing thermonuclear war is that of a threat in being to persuade Russia to abstain, because any use of atomic weapons unacceptably increases the probability of thermonuclear war.

4. Against the improbable prospect of a Russian miscalculation or impulse, we must ensure ourselves with the basic capability to wage a long nuclear war of attrition following the initial all-out exchange.

WE are now ready to apply the principle of selectivity in the accumulation of armed might. This means that we disdain unfettered expenditures and arbitrary allocation of monies among the services in favor of acquiring only those military capabilities best calculated to support a national plan evolved from our four major conclusions.

Selective acquisition would embody concerted pursuit of essential and curtailment of merely desirable programs. It would draw a fine line between force requirements for deterrence (*i.e.,* for defense against enemy intent) and force requirements for insurance against the prospect that the deterred action eventually would take place.

Such a course would recognize that we must not jeopardize our solvency nor our primary defenses by attempting to make secondary defenses absolute or optimum. It would make haste in orderly rather than frantic fashion so as to obviate inflexible, runaway momentum and thereby ensure sensitivity to changing world conditions, advancing technology, and pertubations in the national economy.

Only through selective acquisition can we maximize our prospects of achieving security with solvency.

Military Professionals, II

A commentary on the record of the Manhattan Project in World War II when atomic energy was developed with speed and a minimum of red tape

Lieut. Gen. Leslie R. Groves

• *Mark S. Watson, distinguished military correspondent of the Baltimore Sun, published in the July-August 1958 issue of this journal under the title, "Military Professionals," a penetrating analysis of the place of the professional soldier in the American defense establishment. His was a forthright defense of the thesis that career military men who have the training, knowledge, and experience to carry out their jobs with efficiency and dispatch should be given authority to perform tasks commensurate with their responsibility.*

Many observers in close contact with Pentagon procedures honestly believe that, by downgrading the military professional under numerous civilian executives of limited military experience, many of the problems, delays, and excessive costs of the present gigantic establishment have been brought about.

Mr. Watson's article in these pages created wide and favorable comment. It was read by both civilian and military leaders, many of whom expressed their agreement with his point of view.

The editors have chosen one such opinion from an especially qualified commentator for publication here. After reading Mr. Watson's article, Lieut. Gen. Leslie R. Groves, U. S. Army (Ret.), Director of the famed Manhattan Project in World War II and currently a vice-president of Remington Rand Inc., Stamford, Conn., wrote Mr. Watson the following letter.

General Groves directed the production of atomic weapons with dispatch and success. He was given authority commensurate with his responsibility by the civilian heads to whom he reported, and these were extremely few in number. General Groves' letter to Mr. Watson is published here with permission of its author and recipient.—EDITOR.

Dear Mr. Watson:

I have just read with a great deal of pleasure and approbation your article, "Military Professionals," in ORDNANCE for July-August.

Even in such a tremendous organization as the Defense Department, only one man can set fundamental policy. And it is only fundamental policy that should be set by a nonprofessional.

While Mr. McElroy is apparently making greater use of the military professionals than did Mr. Wilson, the present serious situation can never be corrected until there is a general sweeping out of the amateur operators.

I am positive that we would never have succeeded in the Atomic Project under the conditions now existent in the Defense Department. The conditions under which we operated in World War II were entirely different. I reported directly to General Marshall on all purely military matters and to Secretary Stimson on everything else. General Somervell and, in turn, Under Secretary of War Patterson were kept informed through the former's Chief of Staff, Lieut. Gen. W. D. Styer, a member of the Military Policy Committee, as to the progress of our work.

Admiral King was kept aware of matters vitally affecting the Navy through Rear Admiral Purnell, also a member of the Military Policy Committee. On occasion, I also saw Admiral King and General Somervell. General Arnold was kept informed of matters vitally affecting the air by me.

Beginning about January 1945, Secretary Stimson also took a great deal of interest in important military matters such as our targets in Japan.

I concur most heartily in your statement that Secretary Stimson was the boss. As far as I knew, no one ever questioned that fact. He used special civilian assistants, with two of whom I took up many matters. But these assistants (Harvey Bundy and George Harrison) never appeared to set policies or to make decisions on their own, nor did they keep me from talking to the Secretary whenever I wished. On many occasions they urged me to do so and on others suggested to Mr. Stimson that he should talk with me.

I always looked upon them as means whereby the great burdens of the Secretary could be lightened and whereby also my task could be made easier for me.

One of the dangers of the present organization is that it increases the possibility that the professionals promoted into the key military positions will not have the competence they should. I am sure we all appreciate that the qualities which endear a professional military man to the lower level of civilian officialdom are not those that will in times of peace maintain a sound national defense or a fully competent management of our defense efforts.

Sincerely yours,

(Signed) LESLIE R. GROVES

Arms and the Cavalryman

Sabers, pistols, and carbines were the normal fighting tools of mounted troops in the Civil War, but pikes and lances also were used along with three-inch rifles and smoothbore horse artillery

Fairfax Downey

NEW cavalrymen gripped and tentatively swung their recently issued sabers, a tool of war they had read of but very few had handled. The like of these was the weapon of knighthood in flower, the *arme blanche* of the romances, the blade of "Charles O'Malley" and his Irish dragoons. It flashed bare in a charge like that of the Light Brigade at Balaklava. A sense of martial power flowed from it into the man who wielded it. In 1861 not many suspected that swords, like the lances briefly carried, were on their way toward obsolescence.

The clash of sabers, that most stirring sound in combat, echoed through the Civil War. Though the crack of revolvers and carbines and the thundering cannon of the horse artillery drowned the ring of steel on steel, they did not supersede it. The machine gun, to be the nemesis of cavalry, waited in the wings, little used.

Sabers first issued followed the French pattern. They were later supplanted by the model of 1860, its blade more curved, which came into general use.

BOTH sides manufactured and imported sabers. In the first year the South, with its inferior facilities, was compelled to arm its cavalry with whatever blades it could find, some of them heirlooms taken down from pegs over the mantlepiece. An assortment of early American and Mexican War sabers made some troops look like a group of collectors of antique arms.

Early shortages in the North led one regiment to turn crude wooden sabers on lathes, replicas that drew laughs from spectators yet proved useful for practicing the manual. When real sabers were issued, the men were able to handle them creditably.

This article is a chapter from the forthcoming book on the Battle of Brandy Station, June 9, 1863—the greatest cavalry engagement of the American Civil War.

The author is rightly acknowledged as one of the leading students and writers of our generation on the strategy, tactics, and matériel of the Civil War. His books include: "Sound of the Guns"—the story of American artillery from the ancient and honorable company to the atom cannon and guided missile—(McKay 1956); "The Guns at Gettysburg" (McKay 1958); and "Indian-Fighting Army" (Scribner's; reprinted as a paperbound by Bantam).

Colonel Downey's forthcoming book will be published by David McKay Company in the fall of 1959. All members of the American Ordnance Association will be notified of its exact publication date inasmuch as it will be a selection of the Ordnance Book Service.

On drill grounds sabers whirled in moulinets (like arms of a windmill), suppling wrists. Thrusts, cuts, and parries were practiced dismounted and mounted. Men of awkward squads were apt to miss slashes at dummies as they rode past and hit their horses' ears or legs with unpleasant consequences. The most competent instructors were West Pointers, who had studied fencing at the Academy. Gradually recruits learned to wield the strange weapon.

SLUNG from the belt, its rattle and jangle might betray a patrol; yet when a charging cavalryman had emptied his revolver and there was no chance to reload, his saber, like the infantryman's bayonet, was his weapon of final resort.

Veterans sharpened theirs, though not to a razor edge which would nick and turn when parried. Swung by powerful men, sabers cut into skulls, deep through shoulders, or lopped off arms. Thrusts delivered by a *beau sabreur* were deadly. Sabers, declining through the Indian wars and with the development and improvement of rapid-fire and automatic arms, would linger as long as cavalry rode, although they tended increasingly to be left behind at bases when troops took the field.

The day of their passing was not yet. Brandy Station saw such saber combat, mass and individual, as revived memories of the Napoleonic wars.

The past also lived again when a

Confederate troop was temporarily armed with pikes, which had been in the possession of John Brown and his men when they surrendered in the Harper's Ferry arsenal. Lances appeared when the 6th Pennsylvania Cavalry was equipped with them on the recommendation of General McClellan, who on his foreign tour had admired them as carried by Russian cavalry and had heard of their skillful use by the Poles, the world's premier lancers.

THAT weapon was not altogether strange in America. The 2nd U. S. Dragoons once had been armed with it. In 1847-1848 it had proved formidable in the hands of Mexican lancers. The Pennsylvanians' slender spears, nearly ten feet long, made a brave display with their 3-edged tips and scarlet, swallow-tailed pennons, but the troopers heartily disliked them. They were hazards in wooded country, being apt to be tangled in branches. Soon they were discarded, and the 6th Pennsylvania returned with relief to its original armament of sabers and revolvers.

The handy revolver, notably the Colt six-shooter, remained a cavalry favorite. In charge and close combat it gave a trooper six quick chances to drop his enemy, but reloading was slow and not easy, especially on a restive horse. Powder cartridges must be inserted in chambers, balls pressed in with fingers and rammed home with a lever, and the cartridges primed by pressing caps on cones. If a cavalryman emptied his revolver and had no time to reload, he must resort to saber or carbine.

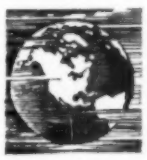
NOT the handgun but the shoulder arm took precedence as dismounted cavalry tactics began to prevail on the battlefield. Here again shortages hampered the South. Numbers of Confederate troopers carried rifles or shotguns, firing buckshot and ball, until factories, imports, or captures from the enemy could arm more with carbines. Those weapons developed from muzzle-loaders to breechloaders, firing brass cartridges, and thence to repeaters.

Against hidebound opposition, requiring President Lincoln's authority to break, the 7-shot Spencer tardily emerged as the king of repeating carbines. Its tubular magazine was inserted through the butt of the stock. The trooper could carry ten extra loaded tubes, making seventy more rounds readily available.

In comparison with other small arms of the day the Spencer became in effect a hand machine gun and gave the Union soldier a tremendous increase in firepower, which the Confederate could not begin to match. Even single-shot, breech-loading carbines could be procured only in limited quantities for the Gray troopers—never more than enough to arm one, perhaps two, squadrons in a regiment, with the deficiency made up by Enfield rifles.

When the day came for Southern cavalrymen to face the withering rapid fire of Spencers, they dubbed them the guns "a Yank could load on Monday and shoot all the rest of the week."

It was almost with a sense of hopelessness that they entered combat in the latter years of the war against



Blue regiments armed with the deadly repeating carbines the South could obtain only by capture. And those few served no longer than their ammunition, equally scarce, lasted.

Spencers, first tried out by the Army of the West on June 24, 1863, were not issued to the Union cavalry until shortly before the Battle of Gettysburg. There, in the hands of Buford's troopers, they played an important part in holding the line in the initial engagement of the first day. What their firepower might have achieved had it been available at Brandy Station on June 9th becomes one of history's most intriguing might-have-beens.

To be reckoned with in many cavalry combats was another weapon, which was used tellingly at Brandy Station—the cannon of the supporting horse artillery. Here again the industrial North surpassed the South by its manufacture of the best gun for the purpose—the 3-inch Ordnance rifle.

Light in weight (about 815 pounds), its 6-horse teams were able to keep up with cavalry, the cannoneers being individually mounted instead of riding on carriages or running beside them as in light artillery. It fired all types of rifled ammunition, its range with shell being about 2½ miles.

Federal 3-inchers were prized trophies; failing them, the Confederate horse artillery used whatever cannon were available, including the short-range, smoothbore Napoleons.

The swift maneuver and rapid fire, which were essential, made horse artillery one of the most dashing arms of the service.

BOOTED and spurred, in short jackets of blue or gray, often with yellow piping, the Civil War cavalryman was a jaunty figure. For the North the forage cap was regulation; Southerners more frequently wore felt hats. The crested helmet and jacked leather cap of the Revolutionary dragoon, which might have spared many a head cut, were not revived. Troopers quickly acquired the swagger and rolling gait of cavalrymen.

Mounted, the Union horseman at first was far from a picture of martial efficiency. Loaded with regular and extra equipment, he and his mount looked like a combination of a one-man pack train and a moving arsenal.

On his person he carried a saber over three feet long in a metal scabbard, a rifle or carbine, and a revolver, a box of cartridges, another of percussion caps, a cloth-covered tin canteen, a coffee cup, and a haversack for rations, plus other devices "recommended to his fancy as useful or beautiful."

All this was in addition to heavy clothing, including an overcoat. The combined weight amounted to some fifty pounds.

Another seventy pounds of weight, besides the trooper's own, was heaped upon his unfortunate horse. Fastened to the saddle was the following appalling conglomeration of items:

ONE or (rarely) a pair of revolvers in thick leather holsters; a pair of saddlebags containing extra clothing, toilet articles, and small belongings. *Cavalry Tactics*, 1841, republished in 1863, prescribed that the contents of the saddlebags be pantaloons, shirts, shaving case, handkerchiefs, gloves,

socks, a second pair of boots, stable jacket, and forage cap; a nose bag, perhaps filled with feed; a heavy leather halter; an iron picket pin with a long lariat or rope for tethering; two horseshoes with extra nails; and a currycomb and brush.

Also carried were a set of gun tools and cleaning materials; a rubber blanket or poncho; one or a pair of woolen blankets; extra utensils, souvenirs, and so on; and sometimes an 8-pound armored vest.

Thus accoutered and armed *cap-a-pie*, the cavalryman seemed to have derived directly from Lewis Carroll's White Knight in "Through the Looking-Glass" who strapped to his horse a deal box, beehive, mousetrap, dish for plum cake, bag of candlesticks, bunches of carrots, and fire irons.

And, like the White Knight, the trooper so burdened "certainly was not a good rider" but fell off in front, behind, and every now and then sidewise. "The great art of riding is to keep your balance."

"When the rider was in the saddle," runs an amusing comment on the Union horseman, "begirt with all his magazine, it was easy to imagine him protected from any ordinary assault. His properties rose before and behind him like fortifications, and those strung over his shoulders covered well his flanks.

"To the uninitiated it was a mystery how the rider got into the saddle; how he could rise to sufficient height and then descend upon the seat was a problem. The irreverent infantry said it was done by the aid of a derrick, or by first climbing to the top of a high fence or the fork of a tree."

GRINNING Rebels, who knew better than to pile such impedimenta, even if they had owned it, on their mounts, wondered whether their Federal opposites were lifted into the saddle after the horse was packed, or whether they mounted and then had the paraphernalia festooned about them.

The answer was that man and beast were loaded, and then the former was given a leg up by one or two comrades. The last man was heaved aboard by two already-mounted troopers.

Of course, horses were unable to carry such weight for long and broke down under it. The story is told of an Irish recruit who noticed his mount's distress and decided to share the load as an act of mercy. He transferred nearly one hundred pounds from the horse to his own shoulders, was helped into the saddle, and rode off jubilant over his unselfishness!

Such surplus baggage was the folly of green recruits, and field service shortly put an end to it. "It became a fine art how to lessen the burden of the horse; and the best soldiers were those whose horses were packed so lightly that the carbine was the biggest part of the load. It was a wonder in the first campaign how a cavalryman could get onto or move his horse when equipped for the field. The wonder afterward came to be how a man could live with so meager an equipment."

The greatest and almost the sole contribution by Maj. Gen. George B. McClellan to cavalry was the saddle he developed and which bore his name. It was a good military saddle, so serviceable that its use by the U. S. Army, with only slight modifications, was continued through the First World War.

An early fault, rawhide covering which split and galled the rider, was eliminated when tanned leather was used. Confederate cavalrymen often adopted this saddle along with other captured Union equipment.

Otherwise McClellan, despite his tour abroad during which he observed the cavalry of foreign armies in action, must be branded the evil genius of the horsemen of the Army of the Potomac from the day he first took over its command to that when he relinquished it. That is all the more deplorable when one considers his great services as an organizer of infantry and artillery.

He was always asking for more cavalry, but when he received it he allowed the regiments to be split up into details of orderlies and escorts for himself and other general and staff officers and to be scattered among corps, divisions, and brigades for use as couriers and pickets for infantry camps.

Smart regiments, which could furnish fine-appearing escorts, were particularly preyed upon and broken up by details, greatly to their personnel's distress, from colonel to private. A whole regiment assembled was a rare sight.

IT is not surprising that the Confederate cavalry, whose commanders seldom stood for such practices, rode rings around or crushed forces of Federal horse, whose strength had been frittered away by detachment or which had never served together as a body since leaving training camp.

Long overdue reorganization did not come until the winter of 1862-1863 when Maj. Gen. Joseph Hooker ordered the horsemen formed into brigades and divisions of the Cavalry Corps of the Army of the Potomac. It was high time. The Union cavalry through no fault of its own had sunk into a slough of inactivity. Hooker himself had succinctly stated the case when, in November 1862, he declared to General Averell: "Well, general, we have not had many dead cavalrymen lying about lately."

The sardonic remark got around. It was picked up and flung at an arm which through late formation and constant attrition from details never had had the opportunity or capability of proving itself. "Whoever saw a dead cavalryman?" gibed weary, trudging infantry at the horsemen who rode past, spattering them with mud.

At Brandy Station both the supporting infantry on that field and Hooker were given a silencing answer when 866 casualties were reported.

> *"The clash of sabers, that most stirring sound in combat, echoed through the Civil War. Though the crack of revolvers and carbines and the thundering cannon of the horse artillery drowned the ring of steel on steel, they did not supersede it. The machine gun, to be the nemesis of cavalry, waited in the wings, little used . . . Sabers, declining through the Indian wars and with the development and improvement of rapid-fire and automatic arms, would linger as long as cavalry rode."*

Soviet Machine Tools

While statistics would seem to indicate that the Russians are producing more such equipment than the United States, further analysis reveals many factors that alter such interpretation

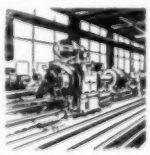
Joseph A. Gwyer

MACHINE tools are of central importance to the achievement of military capability. That the Russians have substantially improved their ability to produce weapons of war is attested by the fact that currently the Soviets are "producing" more than 130,000 machine tools annually.

While granting that the Soviets have made impressive progress, it would be as ill-advised to overestimate this progress as to underestimate it. It may be helpful, then, to assess where the Soviets stand.

Obviously, a comprehensive survey would require extensive analysis of classified as well as unclassified sources. However, a review of unclassified literature does provide a wealth of worthwhile information about Soviet machine-tool resources.

This paper is a preliminary survey of unclassified Soviet literature available to anyone willing to consult the references of the Library of Congress. It attempts to present (1) a historical survey of the Soviet machine-tool industry; (2) data on imports and domestic production of machine tools since 1932 as well as data on the status of Soviet machine-tool inventories; (3) some of the engineering aspects of the industry—*e.g.*, data on types of tools, extent of automation, and characteristic features of some tools; and (4) observations based on these data.



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The reported production figures are those quoted by official Soviet agencies and should be considered as "reported" and not necessarily as attained.

The branches of the engineering industries producing machine tools were weakly developed in pre-1917 Russia. Consequently, the demand for tools was met basically by imports of tools from abroad. The economic and industrial recovery from the effects of World War I and the Russian civil war during the era of new economic policy, which was instituted in 1921 and which attempted to retain Communism only as the principle of government, imposed new demands on whatever industrial establishments were not affected by the ravages of war.

As of 1925, machine tools were manufactured by the Moscow plant "Samotochka," the Kuybyshev (former city of Samara) Middle Volga plant, Odessa plant (Lenin), Izhevsk and Tula ordnance plants, Leningrad plant (Il'ich), Yegor'yevsk plant "Komsomolets," and a few others.[1]

In April 1929, the XVI Conference of the Communist Party officially accepted the first Five-Year Plan (FYP) for the development of the national economy. Among the considerations discussed at the conference was conversion within the shortest possible time of the machine-tool industry from a "narrow and shaky" base into a powerful technical base that could be in position to serve the over-all needs of expanding Soviet industry.[2]

A governmental decree of 1929 created the "Stankotrest" (Machine Tool Trust) which comprised the following machine-tool building plants: Moscow's "Krasnyy proletariy," Leningrad plant (Sverdlov), "Dvigatel' revolyutsii," "Samotochka," "Komsomolets," and the Kuybyshev Middle Volga plant.

THE organization of the "Stankotrest" marked the creation of an independent branch of Soviet industry, solely concentrating on the production of tools. A new trust called "Soyuzstankoinstrument" which also embraced the production of cutting tools, was subsequently reorganized into an All Union Association.[3]

During 1932 the following two new plants were added to the industry: the Moscow machine-tool plant (Sergo Ordzhonikidze) and the Gorkiy plant for building milling machines.[4]

ENIMS (Eksperimental'nyy nauchno-issledovatel'skiy institut metallorezhushchikh stankov—Experimental Scientific Research Institute for Metal

Region	1940	1950	1951	1952	1953	1954	1955
RSFSR (total)	39,500	49,500	48,200	49,200	62,100	69,200	76,400
Northwest	2,553	2,343	2,298	2,630	4,160	4,048	5,161
Center	27,200	21,000	21,200	21,700	27,600	32,600	34,500
Volga area	4,400	6,400	6,800	6,700	6,600	7,500	8,700
North Caucasus	1,362	4,561	4,630	4,904	7,442	8,282	10,251
Urals	2,600	11,600	9,200	9,000	11,400	12,700	12,100
West Siberia	1,382	3,354	3,860	3,970	4,566	3,691	4,562
Ukrainian S.S.R.	11,700	10,500	10,400	12,100	12,900	14,000	14,400
White Russian S.S.R.	6,000	4,800	6,000	6,300	7,700	9,000	11,200
Georgian S.S.R.	803	2,481	2,721	2,757	2,897	3,290	3,942
Lithuanian S.S.R.	—	1,247	855	960	1,789	2,034	5,226
Kirghiz S.S.R.	110	630	725	531	706	860	1,148
Armenian S.S.R.	—	904	1,289	1,540	1,841	2,120	2,773

Source: Tsentral'noye Statisticheskoye Upravleniye pri Sovete Ministrov S.S.S.R., *Promyshlennost' S.S.S.R. Statisticheskiy sbornik*, Moscow, Gosstatizdat, 1957, p. 55, 60, 62, 64, 65, 66, 68, 72, 81, 85, 91, 95.

Table 1. Soviet production of machine tools—1940, 1950-1955 (in units).

Cutting Tools) was organized in 1933 with the primary function of carrying out scientific research for the entire machine-tool building industry of the U.S.S.R.[5] Among its tasks was to determine the most suitable types of machine tools for Soviet industry, designing of new tools, etc.

During the second Five-Year Plan, the following plants were added to the growing roster of machine-tool-building plants: the Kharkov plant for drilling and grinding tools, the Kiyev plant (Gorkiy) for automatic machine tools, the "Stankokonstruktsiya" plant, the plant in Tbilisi (Kirov), and the Saratov plant for gear-cutting machine tools (an experimental shop).

A DIRECTIVE of the Presidium of the Supreme Soviet of the U.S.S.R. dated September 4, 1939, transferred a group of locally administered plants in the White Russian S.S.R. into the larger nationwide complex of machine-tool-building plants.[6] The newly constructed Kramatorsk plant for heavy machine tools entered the complex in 1939.

The directive of the Central Committee of the All-Union Communist Party and of the Council of National Commissars of the U.S.S.R. blueprinted on December 8, 1940, a program for the reconstruction of existing plants and construction of twenty-five new machine-tool plants and six plants for related production, and also for conversion to machine-tool production of numerous other plants.[7]

In order to carry out the December 1940 resolutions regarding the further development of the machine-tool industry, the government created in May 1941 the Ministry for Machine Tool Construction (Narodnyy Komissariat Stankostroyeniya Soyuza S.S.S.R.), which united all specialized enterprises engaged in production of machine tools, press-forging equipment, cutting tools, and abrasives.

During World War II, in connection with the evacuation of machine-tool plants into the eastern regions of the U.S.S.R., the following new centers were added to the industry: Alapayevsk, Sterlitamak, Troisk, Kizel, Sol'-Iletsk, and others.

During the 1946-1950 period, all war-damaged plants were rebuilt, and existing plants were reconstructed. A new plant for heavy machine tools at Kolomna entered production during this period of reconstruction.

The shift in the geographical distribution of machine-tool production since 1940 can be seen in Table 1.

The production of machine tools was organized almost entirely during the first Five-Year Plan.[8] Prior to the outset of the first FYP, such equipment had to be imported from abroad, as was customary prior to the outbreak of World War I.[9]

The XIV Congress of the All-Union Communist Party, held in December 1925, in search of solutions to the critical problem of industrial underdevelopment, decided to support the principle of industrialization at any cost. Since engineering industry was weakly developed in Russia and its recovery had lagged behind that of most other industries as a consequence of the civil war, it was decided that the output of Russian machine tools was to be supplemented by the import of machine tools from abroad.

THE magnitude of imports of metal-working equipment, especially that for machine tools, compared with domestically produced equipment, can be seen from Table 2.

Beginning in 1938, imports of machinery in general, and machine tools in particular, declined to relatively low levels. This decline in imports is attributable to the development of a domestic industry largely capable of supplying the Soviet industry with adequate numbers of machine tools as is evident to some extent from Table 3.

A detailed scrutiny of official Soviet statistics dealing with annual domestic production and imports of machine tools from Germany, France, England, and the United States, combined with a check of machine-tool stocks accumulated as of January 1, 1932, 1941, and 1956, reveals significant discrepancies, which so far have not been pointed out in U. S. technical and economic publications. Table 4 brings together data on existing stocks, production, imports, and losses due to war, etc.

It is apparent that somewhere along the line there is a misrepresentation of statistical data. According to the Soviets, the total stock of machine tools

Table 2. Soviet imports and domestic production of machine tools.

Year	*No. of imported machine tools*	*No. of domestically produced machine tools*
1923-1927	15,524	7,387
1928	5,323	2,697
1929	6,042	4,617
1930	11,352	8,199
1931	18,269	12,846
1932	68,950	19,720
1933	23,730	21,000
1934	18,397	25,400
1935	12,435	33,900
1936	4,888	44,400
1937	4,790	48,473

in the U.S.S.R. between January 1, 1932, and January 1, 1956, rose from 181,000 to 1,760,000, giving a net gain of 1,579,000 units.

DURING the same period the domestic production accounted for 1,231,694 units and imports for 154,735 units. Subtracting war losses of 175,000 machine tools, this leaves us with 1,211,429 units officially accounted for.

Unaccounted for are 367,571 machine tools which the Soviets claim to have but never admitted the manner of acquisition. At this point the author would like to stress that in his calculations he assumes that all machine tools either produced or imported into the U.S.S.R. are still in an operating condition. This is an untenable assumption considering the fact that the number of unskilled tool operators in the U.S.S.R. was and still is extremely high and that the productivity of the Soviet machine tool operator is much lower than that of his American counterpart.[10]

Untenable as it may sound, official figures of the Central Statistical Administration show that as of January 1, 1956, the total stock of Soviet machine tools consisted of 1,760,000 units, including 18.2 per cent, or about 320,320 units of the pre-1936 vintage.[11]

A considerable number of the 367,571 "unaccounted" machine tools probably were acquired by the U.S.S.R. as result of a ruthless industrial pillage of Austria, Czechoslovakia, Eastern Germany, Hungary, Poland, and Manchuria. The extent of the pillage cannot be ascertained, but taking into consideration the fact that Germany during the latter phases of World War II moved large numbers of tools (some looted from France, Belgium, and other areas) into rearward areas to escape Allied bombings, we can safely assume that the bulk of these were taken by the Soviets as "war reparations," etc.

The balance of the "unaccounted" machine tools was most likely supplied by Czechoslovakia, Hungary, and East Germany, whose production of machine tools is steadily rising and whose principal markets are in the U.S.S.R.

Between January 1, 1956, and January 1, 1957, the total stock of machine tools rose from 1,760,000 to 1,840,000 units, a net gain of 80,000 units.[12] During the same period, Soviet industry produced 121,300 units.[13] It is difficult to estimate how many of these units were considered as completed but still in the machine-building plants.

Since the demand for machine tools is great we can only assume that completed units are utilized almost immediately without being stored for a prolonged time in warehouses of producing plants. During 1957, the Soviet machine-tool building industry turned out approximately 130,000 machine units.[14] According to Prokopovich, the production of 200,000 units by 1960 will closely approach the U. S. production of machine tools in 1952, when the industry turned out about 230,000 units of all types.[15]

A CURSORY examination of available data shows that either the replacement of outmoded equipment or modernization (rebuilding) of machine tools practically does not exist in the U.S.S.R. During the past ten years few if any machine tools were scrapped and replaced by new units, and only about 60,000 machine tools were modernized.[16]

The modernization consisted primarily of increasing spindle speeds and power and hardly touched the mechanization and automation of equipment. It is of some significance that the sixth Five-Year Plan provides for modernization of about twenty-two per cent of the operating stock as of January 1, 1956.[17] Should such a bold plan succeed, the modernization would encompass practically all the machine tools in Soviet stock of the pre-1939 vintage.

Since most of the machine tools looted from Central Europe were of the pre-1939 vintage, it is quite safe to

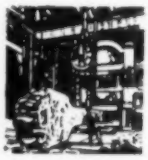
Table 3. Annual Soviet production of machine tools by categories (in units).

Category	1932	1937	1940	1945	1950	1951	1952	1953	1954	1955	1956	1957
Metal-cutting machine tools (Totals)	19,978	48,473	58,437	38,419	70,597	71,182	74,558	91,759	102,362	117,087	121,300	130,000
Lathes	7,145	15,202	11,523	13,063	24,140	23,142	23,853	27,384	29,507	41,292	—	—
Turret lathes	512	1,806	2,088	2,920	1,402	1,583	1,684	2,010	2,378	2,825	—	—
Semiautomatic & automatic lathes	—	894	2,038	419	863	981	1,129	1,237	1,152	1,524	—	—
Milling	1,068	3,243	3,701	1,353	3,857	3,827	4,287	5,022	6,401	7,339	—	—
Gear-cutting	—	397	543	295	1,658	1,941	1,686	1,799	1,689	1,973	—	—
Boring	67	131	124	42	227	327	416	493	606	643	—	—
Planers	233	303	173	5	218	271	343	326	380	453	—	—
Shapers	833	3,172	2,048	628	2,561	2,855	3,147	3,493	3,721	4,559	—	—
Slotting	46	250	158	20	104	169	309	419	540	505	—	—
Broaching	—	44	68	5	179	272	199	224	273	307	—	—
Grinding	254	1,839	2,094	1,832	3,574	4,049	3,185	3,369	3,432	3,959	—	—
Sharpening	221	2,045	4,268	907	1,575	1,700	1,516	1,635	1,543	1,864	—	—
Vertical-drilling	6,838	12,235	15,251	7,168	9,889	11,022	12,962	19,014	22,098	24,921	—	—
Radial-drilling	—	585	610	43	870	1,123	1,388	1,677	1,725	2,000	—	—
File-cutting	—	—	—	—	138	90	10	—	—	—	—	—
Special	—	962	6,688	5,046	8,623	7,560	7,009	8,233	9,533	16,685	21,800	—
Precision	—	—	17	17	2,744	3,179	3,159	4,468	5,161	5,860	—	—
Large, heavy, unique	—	23	212	42	1,537	1,714	1,691	2,338	2,849	3,540	4,733	—
Other	2,503	5,365	7,061	4,673	10,719	10,270	11,435	15,460	17,381	17,238	—	—

Sources: Production figures for 1928-1955 period: Tsentral'noye Statisticheskoye Upravleniye pri Sovete Ministrov S.S.S.R., *Promyshlennost' S.S.S.R. Statisticheskiy sbornik*, Moscow, Gosstatizdat, 1957, p. 207-209. Production figures for 1956: Tsentral'noye Statisticheskoye Upravleniye pri Sovete Ministrov S.S.S.R., *Narodnoye khozyaystvo S.S.S.R. v 1956 godu. Statisticheskiy yezhegodnik*. Moscow, Gosstatizdat, 1957, p. 60; "Sovetskoye . . ." *op. cit.*, p. 3. Production figures for 1957: *Izvestiya*, Jan. 28, 1958, p. 2.

assume that about one-half of the present operating stock is more than eighteen years old. In contrast, the average life before obsolescence of a machine tool in the United States ranges between seven to ten years. This explains the fact that the productivity of the Soviet industrial worker is only about forty per cent that of his American counterpart, and it is not expected to rise above 60 per cent by 1960.[18]

In the beginning of the second Five-Year Plan, the Soviets were producing about forty types of machine tools of a relatively simple design (with cone-pulley drives) chiefly to satisfy the needs created by the machine-building program in general and to some extent for replacement of shop-worn equipment. Prior to the outbreak of World War II, Soviet plants not only stepped up numerically the output of machine tools but also increased the number of types of machines produced to more than two hundred. This increase was primarily noted among general-purpose and special machine tools. These achievements were demonstrated during the All-Union Exposition of Machine Tools held in Moscow in 1938.[19]



During the 1934-1940 period, machine tools using standardized components designed by ENIMS and built by the "Stankokonstruktsiya" plant played an important rôle in the mechanization and automation of machine-building processes and also in the introduction of mass-production methods. With the organizational period ending in 1937, the industry entered the phase of independent technical growth, relying less and less on the aid from the West.

THE production of automatic and semiautomatic gear-cutting, broaching, milling, and special-purpose machine tools for plants employing mass-production methods rose sharply during the latter part of the second FYP and the first two years of the third. In 1938, the Soviets began production of heavy lathes, boring and planing machines, and practically completed the transition from cone-pulley to individual drives on newly produced equipment.[20]

The outbreak of war between the U.S.S.R. and Germany made considerable changes in the assortment of machine-tool types produced, since the demand centered on efficient, simple, and general-purpose machines. During the latter part of the war, with the receding tide of German conquest, plans were already made for production of machine tools for plants in liberated areas.

Consequently, the fourth Five-Year Plan witnessed an increase in the number of specialized, large, heavy, and precision machine tools geared for reconstruction of transportation, industrial, and agricultural equipment. The production of precision machine tools in 1955 reached 5,860 units in comparison with 2,744 units in 1950, and 17 units in 1940 (See Table 3).

Wide introduction of automated mass flow production processes, created during the fifth FYP a great demand for special equipment and machine tools using standardized components and automatic machine-tool lines. The 1956 production of these tools reached 21,800 units in contrast with 8,600 units in 1950.

During the 1950-1956 period, the industry produced 1,257 new, more important types of machine tools, of which about 40 per cent appear to be either automatic or semiautomatic.[21]

A significant contribution to the automation of production processes appears to be the complex automation of automobile cylinder block production as exemplified by the practices of the Moscow Automobile Plant ZIL (Zavod im. Likhachev).

During the past ten years the Soviet industry introduced more than ninety automated lines. Those installed in the Moscow Automobile Plant ZIL, Kharkov Tractor Plant, Moscow First State Bearing Plant, and Altay Plant for Agricultural Machinery are the most outstanding examples.[22]

Throughout 1957, the ENIMS was carrying out an intensive research in order to devise typical automatic lines for production of spur and bevel gears, tapered and splined shafts, and other parts of a general machine-building nature. Each of these lines would permit machining of parts varying considerably in size; resetting of the line would take no longer than two to three hours.

All in all, automation of this sort will undoubtedly help the Soviets to overcome many of their industrial ills and will help make up for a lack of skilled workers.

It is not the purpose of this survey to placate the "alarmist" who daily both extols and bemoans Soviet industrial strides, nor to awaken the uninterested or those who underestimate the Soviet industrial capacity. Production figures, such as those quoted by the Soviets, should always be looked upon and examined in an analytical and objective perspective.

True, the reported production figures for Soviet machine tools during 1955 compared with those for the United States seemingly show that the Soviets outstripped us in that respect by a fairly wide margin.

HOWEVER, a brief insight into what lies behind these Soviet figures shows that the "alarmist" should restrain his extolment and that the habitual "downgrader" should reconsider his estimates and assume objective attitudes toward Soviet industrial prowess. It is true that, tool for tool, the Soviets produced in 1955 more than we did, but the basic question is: What kind and how modern are these tools?

The over-all production of metal-cutting machine tools in 1955 in the U. S. and the U.S.S.R. reached approximately 106,000 and 117,000 units respectively. The figure of 106,000 units for the United States excludes home-workshop, service-shop, garage equipment, etc., while the Soviet figure of 117,000 units includes presumably all types of metal-cutting machine tools, large and small.

The qualification, "presumably," is based on the fact that prior to 1939, the Soviets, in reporting their annual production of machine tools, as a rule excluded small tools.

The Soviet statistical abstract published in 1957 presents only the totals for these years, thus giving grounds for an assumption that the postwar production figures include perhaps up to twenty-five per cent of machine tools

of service-shop and garage variety. Should this assumption be correct, the Soviets even at present are producing machine tools only at a rate of about 100,000 units a year.

THE second question as to how modern Soviet machine tools are can be answered by comparing Soviet machine-tool specifications with those of the United States. It may be assumed reasonably that the bulk of current models turned out by the Soviet industry approach in make-up, speeds, rate of feed, etc., the U. S. models made during the late 1930's and during World War II.

Since then the United States has made considerable advances in machine-tool technology and through the introduction of tungsten-carbide tooling has increased the productive capacity of modern machine tools two to five times.

The figure of 106,000 units produced in 1955 does not represent the capacity of the U. S. machine-tool industry which turned out more than 300,000 units during the height of World War II. At present the industry is basically reproducing itself, is phasing out obsolete equipment, and is producing highly efficient modern units.

Even at the present low rates of production, United States industry annually is turning out machine tools which in their total productive capacity exceed by at least fifty per cent the total productive capacity of Soviet machine tools.

Substantiation of the above statement can be found in a recently released Soviet study of Methods of Measurement of Labor Productivity in Industry, which outlines the basic shortages of the Soviet industry and repeatedly makes references to shortages of certain categories and low productivity of Soviet machine tools.

These are Soviet industrial ills which cannot be cured overnight and which were conveniently forgotten by those to whom the launching of Sputnik meant progress in all lines of Soviet endeavor. The fact remains that Soviet industrial progress is handicapped by slipshod practices and operations.

DESPITE her claim to industrial prowess and her astuteness in the statistical game of numbers, the Soviet Union still remains and will remain for some time to come well behind the United States in machine-tool production.

Table 4. Soviet machine tool stocks, annual production, imports, war losses.

Total Stock of Machine Tools		*Year*	*Machine Tools Produced in USSR*		*Machine Tools Imported from Abroad*		*War Losses etc.*
Date:							
Jan. 1, 1932:	181,000	1932	19,720		68,950		
		1933	21,000		23,730		
		1934	25,400		18,397		
		1935	33,900		12,435		
		1936	44,400		4,888		
		1937	48,473		4,790		
		1938	55,300		n.a.		
		1939	55,000		n.a.		
		1940	58,437		n.a.		
Jan. 1, 1941:	710,000	Total	361,630		132,990		
		1941	29,000				
		1942	10,000	estimate	21,745	Lend	(175,000)
		1943	20,000			Lease	
		1944	25,000				
		1945	38,419		n.a.		
		1946	40,300		n.a.		
		1947	50,400		n.a.		
		1948	64,500		n.a.		
		1949	64,900		n.a.		
		1950	70,597		n.a.		
		1951	71,182		n.a.		
		1952	74,558		n.a.		
		1953	91,759		n.a.		
		1954	102,362		n.a.		
		1955	117,087		n.a.		
Jan. 1, 1956:	1,760,000	Total	870,064		21,745		175,000
		Grand Total	1,231,694		154,735		175,000

Remarks made recently by Mr. Khrushchev in Berlin that the Soviet Union is catching up with the industrial production of the United States appear highly questionable, to put it mildly, when one goes beyond the Soviet Statistical Abstract in search for true data on the growth and development of the Soviet industry.

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New Army Aircraft

The Bell YH-40, service test model of the Army's new HU-1 Iroquois series front-line utility helicopter, above, combines speed and maneuverability with compact design. It is the first turbine-powered helicopter ordered into production by the Army. The Hiller H-23D Army helicopter, below, a 2-place craft powered by a 250-horsepower engine, will be employed for many different types of missions.

Defense Highlights: Monthly Review and Outlook

• **The Budget and Defense.**—Shortly after Congress adjourned, many Defense Department officials took advantage of the opportunity to visit and inspect the many continental and overseas bases, fleets, and forces of the United States. At the same time, at the working level the "indians" in each service were examining the financial problems in preparation for presenting the Defense Department's budget for fiscal year 1960.

In fiscal 1960, the Administration guide line is reported to approach a figure of about $42 billion. It soon became apparent that all the pet projects of the Army, Navy, and Air Force could not be achieved within this sum.

Secretary of Defense Neil H. McElroy is faced with the need to cut some very popular projects drastically. He is backed in this by counselors who point out that this Nation may have more means of delivering offensive and defensive blows than are essential.

There are three intercontinental missile programs—Atlas, Titan, Minuteman. There is also the Strategic Air Force in being and the Polaris weapons system under development. The ICBM's, SAC, and Polaris are profitable weapons only when equipped with high-yield nuclear warheads. Question: What could be cut out? This problem also exists in the intermediate missile field, in aircraft types, and, to some extent, in smaller surface-to-air and air-to-air missiles.

More and more of the Defense Secretary's advisers obviously are realizing that we have reached a stage where it is extremely dangerous to reduce further the favorite whipping boys of budget cuts—manpower and research and development.

• **Thermonuclear Fusion.**—Very quietly the trans-Atlantic argument as to whether the United States or Great Britain had achieved a thermonuclear reaction disappeared from the public eye when it was discovered that no laboratory had yet produced a true fusion but that only secondary thermonuclear particles had been generated.

In the United States the best prospects for attaining true fusion are with the Scylla device at Los Alamos Scientific Laboratory and the DCX at the Oak Ridge National Laboratory. Proof that a true thermonuclear fusion has been obtained is so complicated that the scientists of both laboratories are being very cautious before making any claims, although in both test centers there is great hope of achievement.

In either case, these are purely laboratory equipments where any fusion phenomena would last but a few microseconds. This is a far cry from a useful commercial device.

• **Navy Missile Program.**—The Navy Bureau of Ordnance is making every effort to incorporate weapons systems into the fleet with maximum efficiency and least cost. This program calls for an optimum interchangeability of components between Terrier and Tartar and eventual merging of Terrier with the long-range Talos. In this program the Bureau also seeks to reduce the size and weight of missiles, simplify the parts, and increase the shelf life without jeopardizing effectiveness.

As in all missile programs, the Navy is faced with the ever-present problem of maintaining a sufficient quantity for fleet readiness yet not being overstocked in the face of rapid obsolescence as quantum improvements are incorporated in later types.

• **Reactor Developments.**—In atomic power, Dr. Alvin Radkowsky, Reactor Development Division, AEC, revealed that the life of reactors used in nuclear submarines has been extended by adding special elements to enriched uranium fuel. These parasitic materials, by first slowing down and later hastening the chain reaction, enable larger amounts of uranium to be loaded in the reactor.

The Argonne National Laboratory is increasing its boiling-water reactor output from 20,000- to 100,000-kw. capacity. This experimental reactor is expected to reduce the cost of the resultant electrical energy from 52 to 20 mills per kilowatt-hour. Although this is a major reduction in cost, it isn't yet competitive with the public utilities cost of 7.5 mills from conventional power plants.

Another project at the Arco, Idaho, testing station of the Argonne Laboratory proved successful when its portable low-power reactor achieved criticality. The reactor has a capacity of 3,000 kw. and can be broken down into air-transportable components. Production models will be used on the Distant Early Warning Air Defense lines in Canada.

• **Satellite Struggle.**—While dedicated astronauts work up their multitude of plans for putting man in space, the satellite launchers continue to struggle against the laws of gravity and the vagaries of launching vehicles.

The third Vanguard satellite of the official program was reported to have burned on reentry after a few low-altitude trips around the earth. The exact cause of failure is unknown except that orbital velocity was never obtained. Again rumors circulate that this project may be curtailed, although four more vehicles are ready.

• **Scientific Air Defense.**—The Air Force, with the assistance of the Massachusetts Institute of Technology, has promoted the establishment of a scientific organization that will be its consultant on the integration of weapons into the air-defense system. President of this corporation (Mitre), is C. W. Halligan, formerly director of military engineering, Bell Telephone Laboratories, Inc. Offices will be at Hanscom

Field, near Boston in the building assigned to the Air Defense System's Integration Division. The latter is a recently formed division under the Air Research and Development Command.

The Mitre Corporation will assume much of the work performed by Lincoln Laboratories in developing the Sage air-defense system and will release Lincoln to resume its mission of basic research in Air Defense problems.

• **Streamlined Procurement.**—A bill to streamline procurement was introduced in the last session of Congress too late for serious study but it undoubtedly will come up at the next session. It is a thoroughgoing attempt to reduce the mass of red tape now involved in weapons procurement. Sponsor for the bill, Senator Leverett Saltonstall commented: "We cannot on the one hand criticize the Defense Department for delay and inefficiency when at the same time we impose inordinate administrative burdens through some of our statutes and neglect their modernization."

The major provisions of the bill include the encouragement of competitive negotiations, performance specifications to replace detailed specifications, fixed-price contracts, exemption from renegotiation in some areas, and expansion of the weapons system procurement technique wherein one contractor is designated as a system manager. There are also provisions in the bill to encourage the participation of small business concerns.

• **Nike Hercules.**—While competition quieted as to whether Bomarc or Nike Hercules was the better air-defense missile, the public was acquainted with two sites where the latter missile is now in place. At Fort Tilden, near New York City, a special demonstration was performed for the benefit of company representatives, officers, and newspapermen. In the Washington-Baltimore area, the Nike battery at Davidsonville, Md., was rededicated in a special ceremony after it was converted for the use of the new Nike Hercules in place of the Nike Ajax.

• **Snark Effective.**—Since the Snark intercontinental subsonic cruising missile was put into operational use by the Strategic Air Command, additional capacities become apparent. The engineers were aware of some of the advantages of Snark, but many operational personnel have been skeptical of the weapon because of its low speed. Because of the Snark's small cross section it is almost impossible for early-warning radar to detect it. Furthermore, if high-level attacks are found impractical, the Snark is capable of low-level approaches down to 500 feet.

It is especially attractive to tactical planners in that Snark missiles can be included with conventional bombers to saturate a strongly defended target without suffering unacceptable losses of bomber crews and expensive aircraft.

• **New Sub Fires New Missile.**—The first test of a new submarine and its new armament was successful when the U.S.S. Grayback fired a Regulus II in its first launching of this missile from a submarine. After the launching off Point Mugu, the Regulus, flying at supersonic speed, was guided 200 miles to Edwards Air Force Base where the landing gear failed and the missile crash-landed.

• **Thor Abroad.**—The first of sixty Thor intermediate-range ballistic missiles was airlifted recently to a U. S. Air Force base in England. It will be turned over to the Royal Air Force crews for familiarization and training in handling and check-out procedures.

• **New Seismographs.**—In what appeared to be a last-minute scramble before the October 31st date when we proposed cessation of nuclear weapons tests, the United States installed a number of new-type seismographs. This new type is a long-period seismograph that has already shown great promise in detecting explosions of our own large nuclear devices in the Marshall Islands and Nevada.

It appears that the United States is willing to defer further nuclear testing on a trial basis in the knowledge that it can determine if other nations violate their promise in this agreement, at least in high-yield explosions.

• **Underwater Record.**—The crew of the Navy's second nuclear submarine, the Seawolf, in cruising underwater for sixty continuous days recently set a record that should stand for a long time. Apparently they wished to establish a mark that would not fail during the period the Seawolf is out of action while its reactor is being converted from a sodium-cooled to a water-cooled type.

Although the Seawolf goes in for a long overhaul, the fourth and fifth nuclear submarines, Swordfish and Sargo, have just been commissioned so that our active undersea fleet will not diminish.

• **Incentive Payments.**—The Air Force is overhauling its methods of providing measurement criteria on which to base incentive payments to contractors. The Air Force has proved, too, that incentives, when properly defined and justly measured, increase savings to the Government and profits to the industry.

• **Dart Development Canceled.**—Army Ordnance has canceled further research and development on the Dart antitank missile. Army officials said that other "similar weapons under consideration are in a more advanced stage of development and will be available to equip the armed forces at an early date and at less cost."

As reported in other A.O.A. publications, the French, British, and Australians also have antitank missiles, some of which are operational.

• **Nuclear Propulsion.**—Although it was expected that weapons testing would come to an end, at least temporarily, at the Atomic Energy Commission's Nevada Proving Ground on October 31st, activity in this area will not cease. The extensive programs established or in the making for nuclear rockets and nuclear ramjets will occupy the full time of personnel and facilities in the area.

Stability in Defense

An Editorial

DEEP and growing concern is frequently expressed nowadays both in military and civilian circles about the changing levels on which our national defense is kept from year to year, and almost from month to month. This concern is not alone with the level of public expenditure but also with reference to the ups and downs of the level—at one time on a semihysterical free-for-all basis, at another on limited rations with belt tightened. The pendulum swings from a must-have-it-at-once attitude to stretched-out production and often to complete cancellation.

This is not a new condition in our Republic. National defense with us over a century and three-quarters traditionally has been on a feast-or-famine basis. At the moment, our country and its taxpayers are making great sacrifices to sustain the current needs. But come new Sputniks, and we will do handsprings at vast cost to meet the challenge, only soon thereafter to drop back to a dangerously low status.

The economic waste in such an attitude is largely responsible not only for our confiscatory taxation—it is also the major factor in bringing about our staggering national debt.

A MOST recent case in point is the instability of our policy as it relates to the affairs of the National Guard. Maj. Gen. William H. Harrison, Jr., president of the National Guard Association, in addressing that organization's eightieth national conference recently in Atlantic City, focused attention on the problem by stating:

"You can't turn the faucet on and off all the time. It was at the urging of the Department of Defense that we expended much effort to build up the size of the National Guard a couple of years ago, only to be told this year that the Guard was to be reduced."

While the Guard's strength is to remain at 409,000 officers and men for the current fiscal year, there is no assurance that further effort will not be made to reduce it drastically next year. The Guard, through the State Adjutants General, has proposed a level of 27 infantry divisions and 6 armored divisions. Under the plan the Guard would lose 17 per cent of its existing units, but enlisted strength would remain at about 400,000. Officer strength would be reduced from 45,000 to about 40,000.

In defending the Army position in the matter, Gen. Maxwell D. Taylor, Chief of Staff, addressing the same group, explained that the losses in units and officer strength of the Guard are attributable to the reorganization of each of the twenty-seven Army National Guard divisions into five battle groups of the pentomic type. The larger units mean fewer officers. Essentially, the solution is influenced by the shrinking Army dollar.

It is not our purpose here to dwell upon the Guard's situation. It arises from the same cause that underlies much of our defense instability. General Harrison expresses it well in his phrase, "You can't turn the faucet on and off all the time." His comment applies with equal force to all other elements of the defense team. It applies in a very special and crucial way to our weapons of all classes, ground, sea, air, and space.

Nor is this comment intended to imply that the present high level of public expenditure must continue indefinitely. What we must soon come to see is that there is a safe level in all departments below which we must not go. Once having arrived at it, all hands in military and civilian life, in administrative and legislative areas, will have to give it uncompromising support over the long term, else we will continue to squander our national substance to the ruination of the very way of life we are trying to preserve.

A case of the need to question expenditures is the current study now under way in the Department of Defense relating to continued production of the Jupiter and Thor 1,500-mile missiles. It is right and necessary that such a study be made and steps taken promptly to standardize not only weapons in these categories, but in all other categories as well.

Multiplicity of types is wasteful, both of the taxpayers' money and the fighting man's effectiveness in time of war. Standardization of weapon types must come, and the quicker the better. Only then can our arsenal of weapons, ready for use, grow to vital strength in numbers.

There comes a time in weapon development when unlimited experimentation is lessened and production of standardized types—fewer in number and stabilized in design—gets under way. When that point is reached we will do well to fix upon a level at which the stocks will be maintained and hold to it over a period of years. Determination of both the type and the level are functions of the professionals who will have to fight the battles.

THE final factor of such a stabilized program would be to guarantee a level of replacement at which the old designs of both conventional and nuclear weapons will give way to newly developed types. For example, the great demand for funds to meet the many missile programs now current has resulted in the services scraping the bottom of the barrel to find the money. Many functions which are essential to balanced forces are being neglected in order that missiles may get the lion's share of the available dollars.

Our aircraft are being skimped, maintenance of our ships of the Fleet is being cut back, our tank replacement with newer types awaits the day when, despite our gigantic defense expenditures, there is money in the till to pay the cost.

Stability in defense will help to correct this unhealthy condition. It will come as heartwarming evidence to the taxpayer that the defense dollar is not to be squandered and to the fighting man that if the call should come he will have superior weapons—enough and on time.

ASSOCIATION AFFAIRS

Executive Board Of A.O.A. Electronics Committee Holds Meeting In New York

Dr. George L. Haller, General Electric Company, Syracuse, N. Y., chairman of the A.O.A. Electronics Division, opened the meeting of his executive board at the Drake Hotel in New York, N. Y., on August 27, 1958. Dr. Haller invited Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), A.O.A. staff director for technical operations, to make the introductory remarks.

General Mechling covered the decisions that grew out of the meeting of the Executive Board for Technical Operations which was held in Cleveland on August 14th and emphasized the following points:

Committees within the Electronics Division are now to be known as Sections. Each Section shall be composed of a Steering Committee and consultants. The Steering Committee preferably should consist of not more than twenty members. Consultants will be restricted to members of the armed forces, both uniformed and civilians.

The Steering Committee should meet at least twice a year. The full Section meetings should be held annually or semiannually, and Section consultants should be invited to attend. For at least one general annual Section meeting, members should be invited from the other Sections of the Division through the Section chairman.

Each Section chairman should appoint a deputy chairman and a secretary. These officers will be available to attend Division meetings in addition to or in lieu of the Section chairman.

All present non-Government consultants should be invited to become Section members in order to restrict consultants to the military services, as previously stated. Care should be taken in selecting consultants in order that all the military services may be suitably represented.

In the general discussion which followed these remarks, a number of points were considered.

Among the Government services which were mentioned for consultant participation were: Signal Corps, Ordnance Corps, Department of Defense, Advanced Research Projects Agency, Navy Bureau of Aeronautics, Bureau of Ordnance, and Bureau of Ships, National Aeronautics and Space Administration, Air Research and Development Command, and Air Matériel Command. This list should not be considered as being necessarily complete.

Section members may be from educational institutions or from private life. Generally, Steering Committee members should be from industry. At divisional level only, a public relations director should be appointed who will work in unison with the Division secretary. The reorganization of the Electronics Division should be completed by December 1, 1958 at the latest.

The Division executive board should, as soon as practicable, review its personnel list and its charter. Consideration should be given to the possibility of entering new fields by the present Sections or by additional new Sections. Section activities should be outlined to assist the respective chairmen.

In conclusion, the question was raised as to the desirability of a general Division meeting to include the executive board, Section chairmen and Division consultants. A suggestion was made that the best location might be Washington, D. C., for the convenience of Government consultants.

Proving Ground Instrumentation Group Meets At Naval Air Missile Center

The Proving Ground Instrumentation Committee of the Fire Control Instrument Division met at the U. S. Naval Air Missile Center, Point Mugu, Calif., on July 22 and 23, 1958. This Committee is concerned with problems in the development and design of apparatus required in instrumented range tests of armament. It covers all aspects of data acquisition, transmission, reduction, and computation. The Committee makes recommendations to Government test ranges.

Welcoming the conferees to Point Mugu was Rear Adm. J. P. Monroe, Commander, Pacific Missile Range. Capt. W. B. Miller, U.S.N., range director, followed Admiral Monroe's remarks with a brief introduction.

Comdr. Robert F. Freitag, U.S.N., range planning and development officer at Point Mugu, opened the technical session of the first day with a general presentation on the background, mission, scope, program requirements, and status of the Pacific Missile Range. Dr. William M. Simpson, head of the Pacific Missile Range Group, presented a technical and operational master plan for the establishment of the Pacific Missile Range.

Included was a description of current instrument systems and firmly programmed additions thereto. This was followed by a highlighting of major technical problems and system developments seen as necessary to fulfill Pacific Missile Range requirements. At the conclusion of luncheon, held at the Beach Officers' Club, Comdr. F. P. Morrison, range instrumentation officer, continued this discussion of the master plan.

The remainder of the afternoon was devoted to presentations by Pacific Missile Range personnel of instrumentation problems and possible solutions. The meeting concluded at 4 p.m., with the group reassembling at 6 for a social hour at the Colonial House in Oxnard.

The second day's agenda opened with continued discussion of possible solutions to the problems which were presented by Pacific Missile Range personnel. After luncheon at the Officers' Club, the following informal presentations were given by Committee members:

"Design of Experiments," D. S. Stoller, Rand Corporation; "Radar," Erve Stokes, Radio Corporation of America and Dr. S. W. Herwald, Westinghouse Air Arm Division, Westinghouse Electric Corporation; "Optics," Marvin Friedland, Instrumentation Corporation of Florida, Edward McAllister, Eastman Kodak Company, Thomas Fahy, Perkin-Elmer Corporation, and Jack Clemente, U. S. Naval Ordnance Test Station; "Telemetry and Communication," E. F. Flint, Eastman Kodak Company, and Dr. R. M. Wilmotte, W. L. Maxson Corporation; "Computation and Data Reduction," James R. Belford, International Business Machines Corpora-

tion, M. C. Burns and George Shaw, Radiations, Inc., Dr. Robert L. Dietzold, Bell Telephone Laboratories, Robert M. Kalb and Walter J. Moe, Sperry Rand Corporation, and Ralph McCurdy and Wallace Rianda, Epsco, Inc.

Presiding over the 2-day meeting was Hugh C. Carroll, General Electric Company, Schenectady, N. Y., chairman of the Proving Ground Instrumentation Committee. Mr. Carroll was assisted by Dr. C. W. Miller, Perkin-Elmer Corporation, Norwalk, Conn., deputy chairman of the Committee.

Conferees included: E. G. Ambrose, Jr., Firestone Engineering Laboratory, Monterey, Calif.; D. W. Arnold, Radio Corporation of America, Patrick Air Force Base, Fla.; Mr. Belford; W. R. Bliss, American Machine & Foundry Company, Greenwich, Conn.; Mr. Burns; Mr. Carroll; C. W. Chapman, North American Aviation, Inc., Downey, Calif.; Mr. Clemente; D. Denham, Pacific Missile Range, Point Mugu, Calif.; Mr. Dietzold; Mr. Fahy; Mr. Flint; Mr. Friedland.

Also, R. T. Gabler, Rand Corporation, Santa Monica, Calif.; T. Gaul, Epsco, Inc., Anaheim, Calif.; S. Gavelin, Minneapolis-Honeywell Regulator Company, Los Angeles, Calif.; Dr. Herwald; D. B. Houghton, Franklin Institute, Philadelphia, Pa.; F. Howard, Air Proving Ground Center, Eglin Air Force Base, Fla.; F. S. Howell, Edwards Air Force Base, Calif.; R. L. Johnson, International Business Machines Corporation, Santa Monica, Calif.; Mr. Kalb; J. Kalla, J. W. Fecker, Inc., Pittsburgh, Pa.; A. H. Katz, Rand Corporation, Santa Monica, Calif.

Also, D. M. Latham, Electronic Communications, Inc., North Hollywood, Calif.; J. C. Mace, Firestone Engineering Laboratory, Monterey, Calif.; Mr. McAllister; Mr. Moe; E. Noble, White Sands Missile Range, N. Mex.; D. Parsons, Sandia Corporation, Albuquerque, N. Mex.; N. C. Peterson, Rand Corporation, Santa Monica, Calif.; B. W. Pike, U. S. Naval Air Missile Center, Point Mugu, Calif.

Also, R. R. Potter, U. S. Naval Proving Ground, Dahlgren, Va.; D. Reuyl, Ballistic Research Laboratories, Aberdeen Proving Ground, Md.; Mr. Rianda; Mr. Shaw; Mr. Stokes; Mr. Stoller; Dr. Wilmotte; W. G. Wurz, Instrumentation Laboratories, Yuma Test Station, Yuma, Ariz.; and R. S. Zug, Development and Proof Services, Aberdeen Proving Ground, Md.

Florida Post's Patrick Chapter Holds Luncheon To Start Membership Drive

In the South, one of the newest units of the A.O.A., the Patrick Chapter of the Florida Post, held a special luncheon on July 22nd to introduce its drive for new members in the area that surrounds Patrick Air Force Base and the Cape Canaveral missile-launching complex. Host of the meeting was G. T. Willey, vice-president and general manager of the Martin Company's Cocoa, Fla., organization, who welcomed representatives from over twelve missile industries and the armed forces.

Col. L. M. Orman, chief of the Army Ballistic Missile Agency office at Patrick, as guest speaker outlined the many advantages to both companies and individuals of A.O.A. membership that should be explained to prospective members.

The Patrick Chapter, organized on May 28th under the sponsorship of the Florida Post with headquarters at Eglin AFB, is already off to a flying start with almost 100 members and looks forward to many years of successful operation.

Attending the Patrick Chapter's membership luncheon were, left to right: G T. Willey, vice-president and general manager of Martin-Cocoa, the host; Col. L. M. Orman, chief of ABMA at Patrick AFB; Col. E. G. Woodrich, Chapter chairman; and W. P. Wood of Martin-Cocoa, chairman of the local Membership Committee.

Washington Post Sponsors Annual Golf Tournament At Army-Navy Country Club

The Golf Tournament of the American Ordnance Association sponsored by the Washington Post was held on Monday, September 15th, at the Army-Navy Country Club under perfect weather conditions. Competition for both A.O.A. cups was spirited with several men tied for runner-up.

The Benjamin F. Fairless Cup, presented annually by United States Steel Corporation for best gross score, was won by J. M. Gambatese, associate editor of *Nation's Business*, with a 74. International Harvester's James L. McCaffrey trophy went to D. D. Elrod of Westinghouse Electric Corporation for the low net of 70.

Runners-up for the United States Steel trophy were Col. J. H. Jennette, U.S.A.F., J. C. Lindley, and W. F. Porter, tied at 75. The two tied for second place low net, were Capt. H. C. Mason, U.S.N., and W. Bison.

An informal reception and dinner, attended by many latecomers in addition to golfers, was followed by presentation of golf prizes and drawings for door prizes. F. B. Reybold, general chairman for the day, welcomed the members and guests. C. M. Featherstone, golf chairman, then introduced the officials of the corporations that established the trophies. Thomas Auginbaugh, vice-president of International Harvester Company, who presented the cup to Mr. Elrod, and William A. White, vice-president of United States Steel, who awarded the Fairless trophy to Mr. Gambatese.

In addition to miniature cups and golf equipment for the two trophy winners, many special prizes were awarded. Not only were the runners-up recognized for their good play but many others received a memento for special feats such as birdies on selected holes and highest gross score.

In the horseshoe-pitching department, the Post's genial master of the shoes, Jim Clark, Navy Bureau of Ordnance, chairman of that activity, made the awards for the winners and runners-up in single and doubles matches.

Every member and guest was presented with a small barometer, advance consolation in case he failed to win in the drawing for prizes.

Kenneth Hampton dispensed the door prizes in his precise and stentorian manner. The lucky ones carried off radios, fine luggage, home appliances, and many smaller but useful articles.

Especial thanks were voted for Col. Melvin B. Harris of the Budd Company who engineered the arrangements for refreshments and meals. The meeting was a successful one in every department.

General Hinrichs Discusses Army's Weapons At Northwest Post Meeting

Maj. Gen. John H. Hinrichs, Chief of Ordnance of the Army, was the honor guest and principal speaker at the fall meeting of the Northwest Post of the Association on September 16, 1958. More than 300 representatives of the services and industry from the Minneapolis-St. Paul area and more distant cities were present to hear a timely message on Army Ordnance progress by its Chief. The meeting was held at the Pick-Nicollet Hotel, Minneapolis.

Glenn E. Seidel, president of the Post and vice-president of Minneapolis-Honeywell Regulator Company, presided. General Hinrichs gave an impressive account of the present status and some future plans regarding soldiers' personal weapons, conventional armament, and the new atomic types. As to the first category he said:

"American light-weapon firepower has always been one of our strengths. As battle conditions change, old weapons are improved, and new ones come off the drawing boards and production lines. Victories go to the men who control the combat area with their firepower and their ability to occupy and hold ground. In anything less than the nuclear holocaust, this maxim still holds.

"If we use small atomics there will be areas—as much as fifty per cent of the battlefield—which will be loaded with surviving strong points and fighting men. Our small arms and lighter weapons must furnish our soldiers the punch to seize and hold that ground.

"Our troops must move fast, carry their weapons and ammunition with them, and have the strength to fight hard when they arrive at their objective. A high Ordnance priority has gone to antipersonnel small arms and more powerful weapons that stop tanks, smash bunkers, and still require little more than a strong infantryman or two to put them in firing position. Such weapons approach the equivalent of hand artillery for the front-line soldier.

"So the new developments, modern and lethal as they are, do not make obsolete the more conventional personal weapons of a soldier—rifles, machine guns, mortars, and light rocket launchers. The rifle carried by most infantrymen today is the M1, standard since 1936 and still the best all-around rifle available in large quantity anywhere in the world today.

"The U. S. Army Springfield M14, which is simpler, lighter, and which will deliver more firepower, now goes into production. It will cut the number of types of small arms from four to one and fire the 7.62-mm. cartridge, which will be common to all the NATO allies—a great logistical advantage.

"Similarly the M60 general-purpose machine gun will replace the three caliber .30 machine guns now in use. It also will fire the 7.62-mm. NATO cartridge.

"These two new infantry weapons will greatly simplify battlefield supply problems by reducing the types of small-arms ammunition and simplifying handling and maintenance. They also will reduce the training time for the combat soldier.

"Recoilless rifles give infantry the firepower of artillery at the shorter ranges. The bazooka, now obsolete, stopped German and Japanese tanks in World War II, and its big brother, the 3.5-inch bazooka, proved deadly against the Russian-made T-34 tanks in Korea.

"The modern 106-mm. recoilless rifle, of course, greatly outdistances earlier models in both range and power. Perfected about 1954, its primary purpose is to provide a weapon at battalion level to defeat armor. It will defeat any tank in the world. It shoots several types of projectiles more than 1,000 yards. It is effective against personnel, gun emplacements, caves, and other targets.

"Like all the new weapons, the 106-mm. BAT was designed to obtain great destructive power, ample range and accuracy, and a maximum rate of fire with minimum weight.

"The mortar is not only one of the oldest but also one of the most effective pieces of battlefield equipment. Simple to make and use, it often has been credited with more casualties among front-line troops than any other single weapon. In proportion to its weight, the mortar is one of the most effective and one of the most feared weapons the infantry has. But it is an 'oldy.' It goes back to very early times and was employed by the Chinese, among others. Our mortars—the deadly 81-mm. and big 4.2-inch, have greater accuracy and longer ranges and more power than ever before."

Discussing the future of artillery, General Hinrichs continued:

"Today we have developed some new weapons, and improved some of the older ones. We have modern mobile guns and howitzers and a modern family of tanks. These must serve with rockets and guided missiles in nonatomic warfare, or as vital supplements to battlefield atomics. I believe that they will never be outmoded entirely. I believe we must continue to improve them. Tanks and artillery (whether tubed or 'firenshpitter' type) must be closely coördinated in the battle groups of combined arms to keep them on the move and with the power to hold what is gained in the attack. . . .

"The new 175-mm. gun first shown to the general public in October 1956, is one of the most versatile field-artillery pieces in the Army's arsenal. Its capabilities are in many ways superior to the combined features of the 155-mm. gun, the 8-inch howitzer, and the 8-inch gun. (We have an 8-inch atomic shell, by the way.) So the 175-mm. gun should replace a couple of those weapons when we can get enough from production. It can fire in a complete circle and can occupy its firing position and start firing in 10 to 15 minutes. No recoil and spade pits are necessary.

"By 1954 the Army had rounded out its postwar family of tanks which had been under development since soon after the end of World War II. This family includes the M41 light-gun tank, the medium-gun M48 or Patton 48, and the M103, the first heavy tank ever produced in significant numbers in the United States. I should emphasize that we are not resting on that family but are working on new models today.

"The M48 is probably the toughest and most effective medium tank in the world. The new M48's are equipped with a highly effective control mechanism which makes it possible to hold the 90-mm. gun on target and fire it repeatedly while the tank is moving.

"The new heavy tank, the M103, is the most powerful tank ever produced for the U. S. Army. Weighing about sixty tons, it is armed with a 120-mm. high-velocity gun, the largest ever mounted on a U. S. tank and matching any known tank gun in the world."

General Hinrichs also described in detail the progress and policies relating to Nike-Ajax, Nike-Hercules, Corporal, Honest John, Little John, Lacrosse, Sergeant, Redstone, Pershing, and the Jupiter—all current members of the family of Army Ordnance missiles and rockets.

General Hinrichs directed for Army

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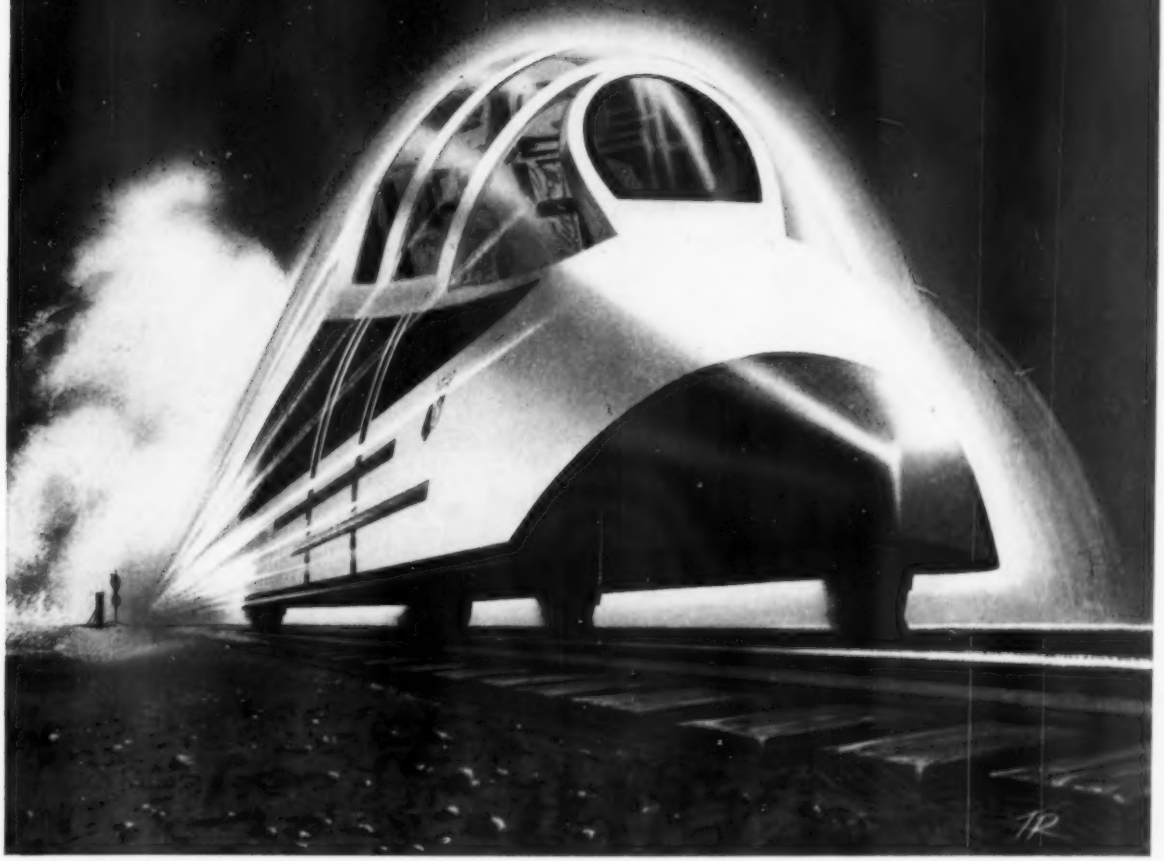

Ordnance in the years prior to World War II the building and operation of the Twin Cities Ordnance Plant, a facility for the production of small-arms ammunition, operated by the Federal Cartridge Company. His popularity among his coworkers of those days in Minneapolis and St. Paul has not diminished as was evident from the presence at the meeting of many of his wartime associates.

Arrangements for the meeting were under the joint direction of William D. Owens of Minneapolis-Honeywell Regulator Company and William B. Horn of Federal Cartridge Company. Present at the speakers' table were Charles Horn, a founder of the Northwest Post and long an ardent and effective proponent of military preparedness; Paul Wishart, president of Minneapolis-Honeywell; Maj. Roland Wilson and Col. A. J. Stallard who were among the founders of the Post. Col. Leo A. Codd, executive vice-president of the A.O.A., also addressed the meeting.

Ground Support Equipment Section Holds Two-Day Meeting In New York

The Ground Support Equipment Section of the Missiles and Astronautics Division held its first annual meeting at the Statler-Hilton Hotel, New York, N. Y., on September 16 and 17, 1958. This Section is concerned with the development, production, and logistics for the broad field of ground support equipment required for missiles and rockets, including all handling and launching equipment, except ground components with guidance and control systems.

Presiding over the 2-day technical sessions was Section Chairman E. A. Brittenham, Jr., Goodyear Aircraft Corporation, Akron, Ohio. Mr. Brittenham was assisted by his deputy, Warren R. Stumpe, American Machine & Foundry Company, Greenwich, Conn. Mr. Stumpe served as meeting manager for the entire program.

Chairman Brittenham, after his own introductory and welcoming remarks, introduced Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), A.O.A. staff director for technical operations, who brought the sincere greetings and best wishes for a successful meeting from national A.O.A. Headquarters.

The technical agenda for Tuesday afternoon, September 16th, included the following four presentations by military representatives from the Army, Navy, and Air Force: "Ammunition Handling at Sea," Capt. C. B. Bright, U.S.N., Office, Chief of Naval Operations; "The Missile—A Unit of Striking Power," Col. J. S. Bleymaier, U.S.A.F., assistant director of Astronautics, Headquarters, Air Research and Development Command; "Ground Support Equipment for Guided Missile Systems," Lieut. Col. S. Skeiber, Army Ordnance Missile Command; and "The Use of Standardized Components in the Design of Ground Support Vehicles," Col. R. H. Hemion, director of Research and Development, Ordnance Tank-Automotive Command, Detroit Arsenal.

An official reception and banquet were arranged Tuesday evening in the Ivy Suite of the Statler. Rear Adm. W. V. R. Vieweg, U.S.N. (Ret.), Electric Boat Division, General Dynamics Corporation, Groton, Conn., served as banquet toastmaster and introduced the guest of honor and principal speaker, Capt. N. G. Ward, U.S.N., Commander, Submarine Squadron 14.

Captain Ward gave an interesting and extremely informative presentation of water-based missile-launching systems with stress on the fact that naval vessels in general and submarines in particular provide, at sea, all those elements of support essential to a successful launching that are found spread over a considerable area in the case of shore-based installations.

Four seminars, with both military and industrial moderators participating, provided the Section program for Wednesday morning. The panels and their moderators were: *Launching Equipment*, J. Dubin, Martin Company, and Lieut. Col. F. E. Brandenberry, U.S.A.F., Equipment and Materials Division, Headquarters, Air Research and Development Command; *Handling Equipment*, M. V. Kadlick, American Machine & Foundry Company, and H. Fronc, Bureau of Ordnance, United States Navy; *Transportation Equipment*, W. B. Pashkow, Mack Trucks, Inc., and Colonel Hemion; *Base Facilities*, R. Ginsberg, American Machine & Foundry Company and B. L. Trawickey, chief of the Missiles Branch, Office of the Chief of Engineers.

At the conclusion of luncheon in the Ivy Suite, the conferees departed via bus for the Brooklyn Plant of American Machine & Foundry Company to view a display of the Titan launcher system. Mr. Stumpe welcomed the group on behalf of

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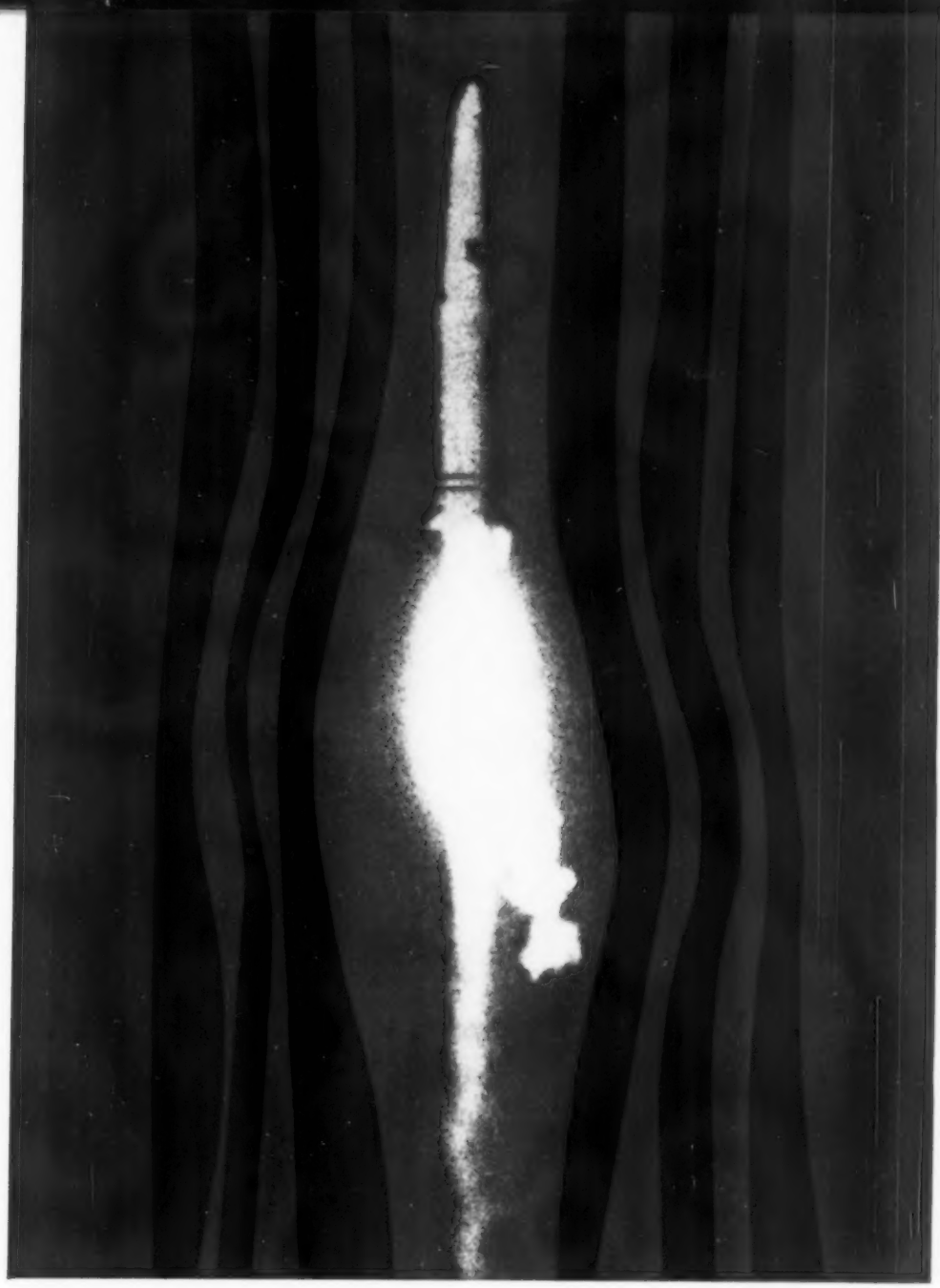

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his company and then introduced H. Lipchick, chief project engineer, American Machine & Foundry Company, who explained the launcher system and its operation to the group. A film and tour of the display area concluded the meeting.

Philadelphia Post Officers And Directors Welcome New Officials

The officers and directors of the Philadelphia Post met at the Union League Club, Philadelphia, Pa., for a luncheon on September 22nd to welcome new directors and bid farewell to Col. Henry R. Thayer, outgoing commanding officer of the Philadelphia Army Ordnance District.

Over two-thirds of the officers and directors were present when Post President Weber deVore called the meeting to order. He introduced the assemblage all around and outlined the agenda for the meeting.

The program for general Post activity was presented by Capt. J. M. P. Wright, from National Headquarters. Col. Henry N. Marsh, a director of the Post and the national organization and general chairman for Technical Divisions, Sections, and Committees, described the plans to revamp the organization of technical activities and the program in process for broadening participation by A.O.A. members.

Colonel Thayer, in thanking the Philadelphia Post for frequent assistance to the Ordnance district, also made suggestions for future activities in the Post. One of special interest was to conduct monthly seminars in technical fields, especially for the young members. Colonel Thayer is now in the Office of the Army Deputy Chief of Staff for Logistics.

E. B. Webster, past Post president, publicly thanked Colonel Thayer for his steady support and thoughtful assistance to the Post during the three years he has served as commander of the Philadelphia Ordnance District.

After considerable discussion the board concurred in plans for the coming year comprising a special seminar at Franklin Institute in the early fall, a plant visit and dinner meeting in December, preferably in the Wilmington area, and a spring meeting at the Naval Air Material Test Center, Johnsville, Pa.

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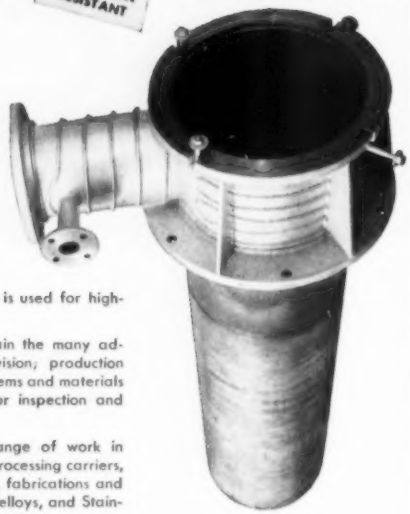

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Albuquerque Post Opens Fall Season With Meeting, Address On Space Conquest

The Albuquerque Post opened its season with a gala fall meeting at the Alvarado Hotel, Albuquerque, N. Mex., on Monday, September 29th.

A record attendance of over 300 members and guests was on hand to greet the guest speaker, Dr. Kraaft A. Ehricke, and bid farewell to Dr. James W. McRae who was leaving his duties as president of Sandia Corporation.

Joe O'Connell, president of the Post, as presiding officer presented a certificate of appreciation on behalf of the American Ordnance Association to Rear Adm. W. W. Juvenal in recognition of his outstanding leadership in the formation of the Post and as its past President. Mr. O'Connell also voiced his appreciation of the support the Post had received from Dr. McRae and the personnel of Sandia Corporation.

R. P. Tinnin, president of the Albuquerque Chamber of Commerce, presented a citation to Dr. McRae on behalf of all the citizens of Albuquerque for "outstanding service to his nation and community."

Dr. Ehricke, assistant chief engineer, Convair Astronautics Division, then discussed the "Conquest of Space." Illustrating his lecture with film slides, Dr. Ehricke touched on problems of space flight, explaining the types of fuels providing maximum propulsion with the least amount of volume, and underlining the importance of the missile in America's quest for supreme space technology. He explained that, by sampling various fuels in each missile firing, the ideal type propulsion will be developed.

Dr. Ehricke pointed to four basic rocket space missions: (1) Earth-to-satellite for cargo or personnel transport; (2) satellites for research, military advantage, and refueling; (3) satellite-to-spaceship; and (4) moon vehicles for research and interplanetary probes.

He explained that present vehicles are chemically propelled, but that future fuels which will give greater thrust for space-fighters will be of solar, nuclear, or fusion type.

Dr. Ehricke also showed America's current space missiles—the Vanguard, Jupiter, Thor, Atlas, and Titan.

The invocation was delivered by Chaplain Ellis R. Veach, Major, U.S.A.F. Others at the head table were: C. W. Lytle, National Council representative;

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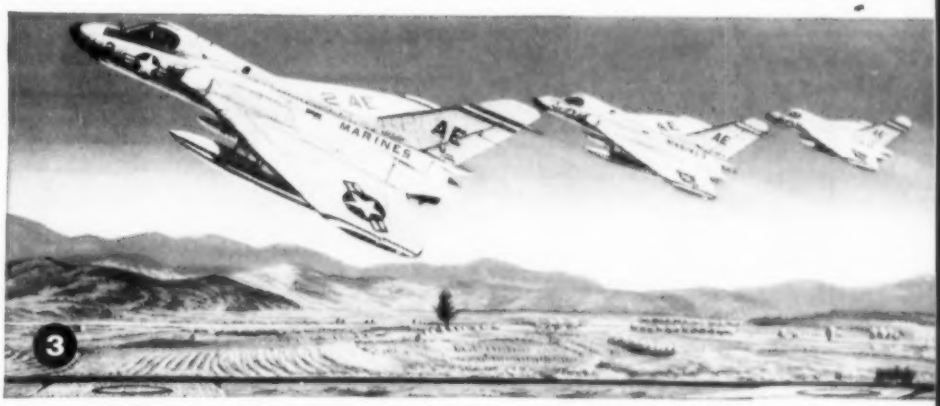

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Designed to detect both close-in and distant supersonic aircraft and missiles, TEW also determines their height—combining the functions of two present radar systems. Its operation is almost completely automatic, requiring only one operator to monitor its control console. Radar console and rotating antenna are housed in an inflatable radome, while the combat interceptor control shelter which completes the TEW system is located nearby. Both can withstand the rigors of arctic or tropical climates.

With its very long range and portable construction, TEW provides the Marines with the means to extend the nation's defense perimeter and insure added protection for key installations and outposts. Like the new super-radars developed by Sperry for the Navy's missile cruisers, TEW is an important contribution to our growing power to deter aggression.

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At Albuquerque meeting were, seated, left to right: Maj. D. L. Schmucker, Post secretary; Rear Adm. L. V. Julihn, vice-president; Dr. K. A. Ehricke, guest speaker; J. J. O'Connell, Post president; Clark Read, director; Standing, l. to r., C. W. Haig, Jr., Lieut. Col. J. M. Banks, E. W. McDougall, and Rear Adm. W. W. Juvenal, Post directors; B. H. Bright, vice-president; W. T. Geyer, treasurer; Maj. R. A. Poe, director.

Maj. Gen. L. T. Heath, commander, Field Command, Armed Forces Special Weapons Project; Rear Adm. Courtney Shands, deputy commander, Field Command, Armed Forces Special Weapons Project; Maj. Gen. Kenneth F. Hertford, retired, manager of the Albuquerque AEC operations; Maj. Gen. Emmanuel Schifani, adjutant general, New Mexico; Col. H. D. Aynesworth, deputy commander, Field Command, Armed Forces Special Weapons Project; Rear Adm. L. V. Julihn, retired, vice-president of Albuquerque Post; and Col. Carey L. O'Bryan, chief of staff, Air Force Special Weapons Center.

During the meeting Mr. O'Connell introduced the following new officers and directors of the Association: R. V. Taborelli and B. M. Bright, vice-presidents; Maj. D. L. Schmucker, secretary; W. T. Geyer, treasurer; and Lieut. Col. J. M. Banks, Edward McDougall, Admiral Juvenal, Maj. R. E. Poe, Otto H. Roehik, Clark Read, and C. W. Haig, Jr.—all Post directors.

Puget Sound Post Members Hold Fall Meeting At Larson Air Force Base

Members of the Puget Sound Post arrived at Larson Air Force Base, Wash., early in the morning on Friday, September 19th, for their annual fall meeting. Because of the large crowd and a last-minute reschedule of Air Transport, the party was taken into Larson from Seattle in two trips, adding greatly to the excitement.

At the base, the rounds were made of the static display, the radar approach control center, the weather control center and the flight test activity.

At midmorning Col. L. F. Johnson, commander, 62nd Troop Carrier Group, welcomed the members and gave a briefing on the mission of his group. He was followed by Col. G. J. Martin, director of base maintenance; Col. L. W. Ford, commander, 4721 Air Defense Group; and other officials of the base who described the duties of their particular branches.

Luncheon was served at the Officers' Club with Post President Lyle A. Wood presiding. The guest of honor was Col. J. M. Hutchison, commander of Larson Air Force Base. Col. Marmion D. Mills, former president of the Post, was presented with a certificate of appreciation for his outstanding services.

After luncheon, the members gathered at the alert hangar and observed a jet scramble as part of a general air defense test exercise.

After the party was fully acquainted with all the techniques used in this center to defend the U. S. against enemy air attacks, they returned to the main field for the hour's run back to the King County Airport in Seattle. Among the A.O.A. members in the party were Post Directors Ernest Jones of Skagit Steel & Iron Works; Fred Young, Boeing Aircraft Company; M. J. Williams, San Francisco Ordnance District; and Fairman B. Lee, Post secretary-treasurer.

Aberdeen Post Directors Meet To Plan Program Of Activities For Coming Year

The Aberdeen Post board of directors met at the Baltimore Country Club on

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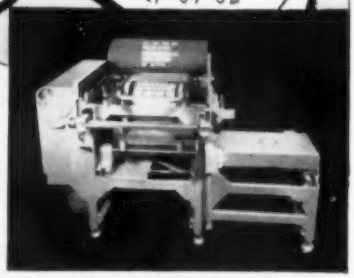

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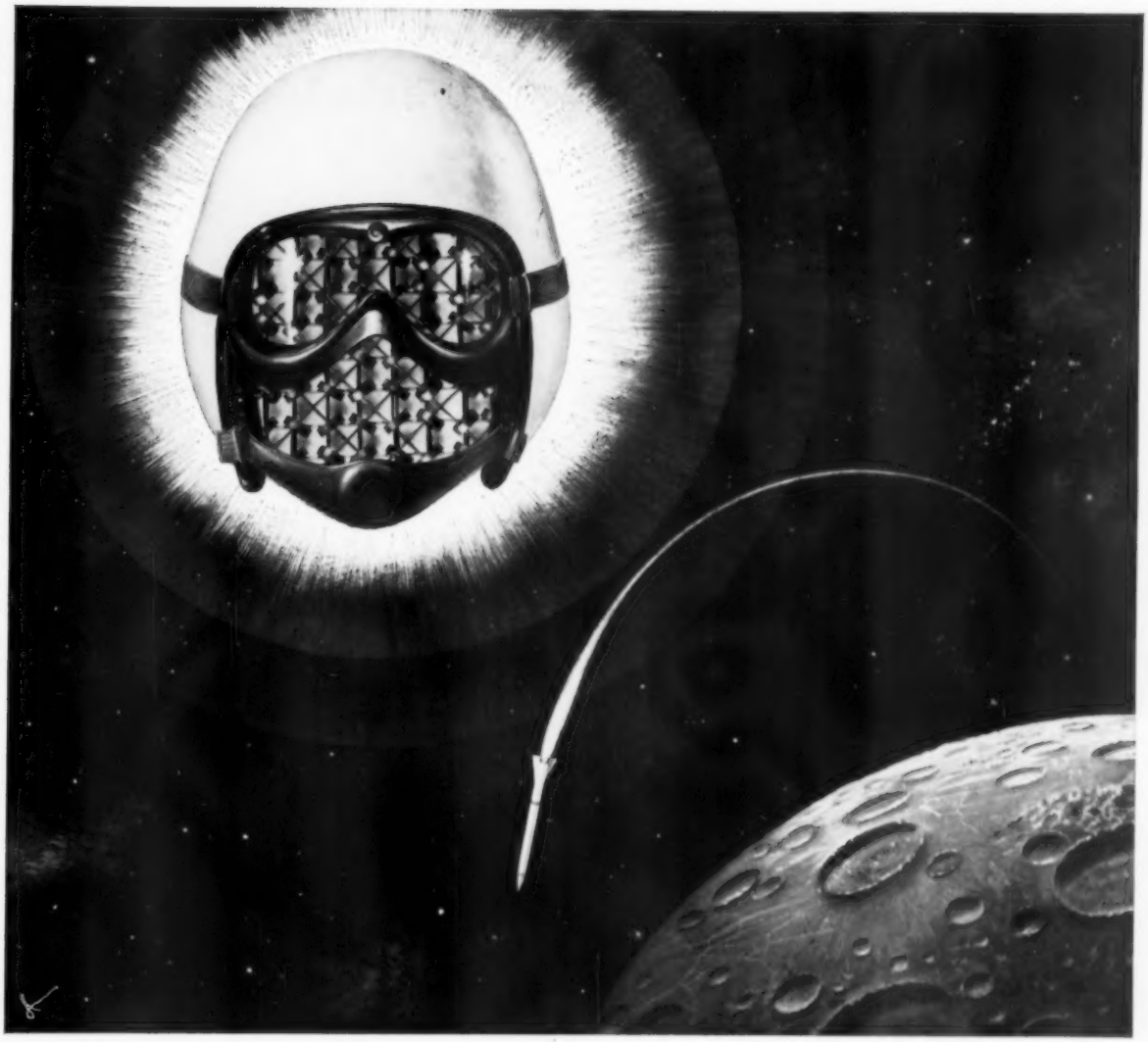

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ELECTRONICS FOR INDUSTRY AND NATIONAL DEFENSE

Wednesday, October 1st, to launch the program for the coming season:

Rear Adm. W. E. Cleaves, Bendix Aviation Corporation, Post president, presided. All directors were present, as follows: Col. F. R. Swoger, Aberdeen Proving Ground, Md., and Joseph M. Schiavetti, Ellicot Fabricators, Inc., Post vice-presidents; Directors William E. Vaughn, Aberdeen Proving Ground; W. D. Smith, Martin Company, Baltimore; Morris D. Kaplan, Aberdeen Proving Ground; Dr. E. E. Minor, Aberdeen Proving Ground; Charles D. Nitchie, Koppers Company, Baltimore. Francis X. Kelly, information officer, Aberdeen Proving Ground, and Capt. J. M. P. Wright from National Headquarters, also were present.

After the luncheon many suggestions were put forward in support of a varied and active season. It was decided to hold three meetings during the year—a dinner meeting in the fall at the Bendix plant restaurant, a social meeting in midwinter, with the big event of the season being a spring meeting at Aberdeen.

A membership committee, led by Mr. Schiavetti and E. D. Cummings was appointed by Admiral Cleaves in expectation of further expanding the membership in the Aberdeen-Baltimore area.

Admiral Cleaves was elected national Council representative, H. Storath was appointed Post secretary, and Dr. E. E. Minor accepted the office of treasurer.

• **COL. CHARLES R. BAXTER,** former editor of this journal and secretary of the Association, died at Kalamazoo, Mich., September 17, 1958. Since his retirement from active business he had lived in Constantine, Mich. He was editor of ORDNANCE from 1927 to 1929, during which time he continued the high plane on which the magazine was founded and broadened its appeal, especially among junior officers of the services.

Born at Chillicothe, Mo., Colonel Baxter was graduated from the United States Military Academy at West Point in 1911. He served first in the Coast Artillery and later was detailed to the Ordnance Department in which he served with distinction until 1937 when he retired to become associated with industry. His Army Ordnance career was marked by assignments where his unusual talents were most beneficial to the service.

He conducted the vast operations of the Ordnance Salvage Board following the First World War where he had supervised the building of the Ogden Arsenal, Ogden, Utah. Later he served several tours of duty at the Rock Island Arsenal, Frankford Arsenal, and the Office of the Chief of Ordnance in Washington. He was a graduate of the Harvard School of Business Administration.

Following his retirement from active military service in 1937, Colonel Baxter became an official of Kendall Mills and later production vice-president of Bauer & Black. In both assignments he was exceptionally successful. Upon the advent of the Second World War he returned to active duty in the Office of the Chief of Ordnance, serving first as assistant to the Director of Fiscal Operations and later as a representative of the Department on the War Production Board.

At war's end he returned again to private life and, until his recent retirement from Bauer & Black, made his headquarters in Chicago. For the past several years he had lived at Constantine, Mich.

Colonel Baxter's service to the Ordnance Association came at a time when his prudence and ability were of great advantage. He bolstered the financial condition of the organization, instituted fiscal policies which have been followed until the present, and gave generously of his experience gained in both military and civilian life toward meeting the editorial needs of this journal. His services and personality will hold high place in the annals of the Association, for he was among the stalwarts who helped it through its formative years.

• **WILLIAM H. MITCHELL,** a charter member of the American Ordnance Association, member of Council, and formerly chief of the Cincinnati Army Ordnance District, died at his home in Cincinnati on September 16, 1958. He was president and treasurer of Mitchell Steel Company.

In addition to his long interest in the activities of the Ordnance Association in connection with the Cincinnati Post, he also served as chairman of the Association's Forging Committee. His wide experience in forging operation in all fields of ordnance production was of inestimable value in the advisory work of that Committee.

He served as chief of the Cincinnati Ordnance District from 1947 to 1950. During World War II he organized the Ridgewood Steel Company at Carthage, Ohio, for the manufacture of gun tubes and steel forgings for Army Ordnance.

(Continued on p. 437)

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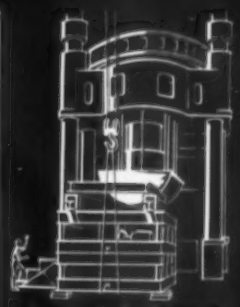

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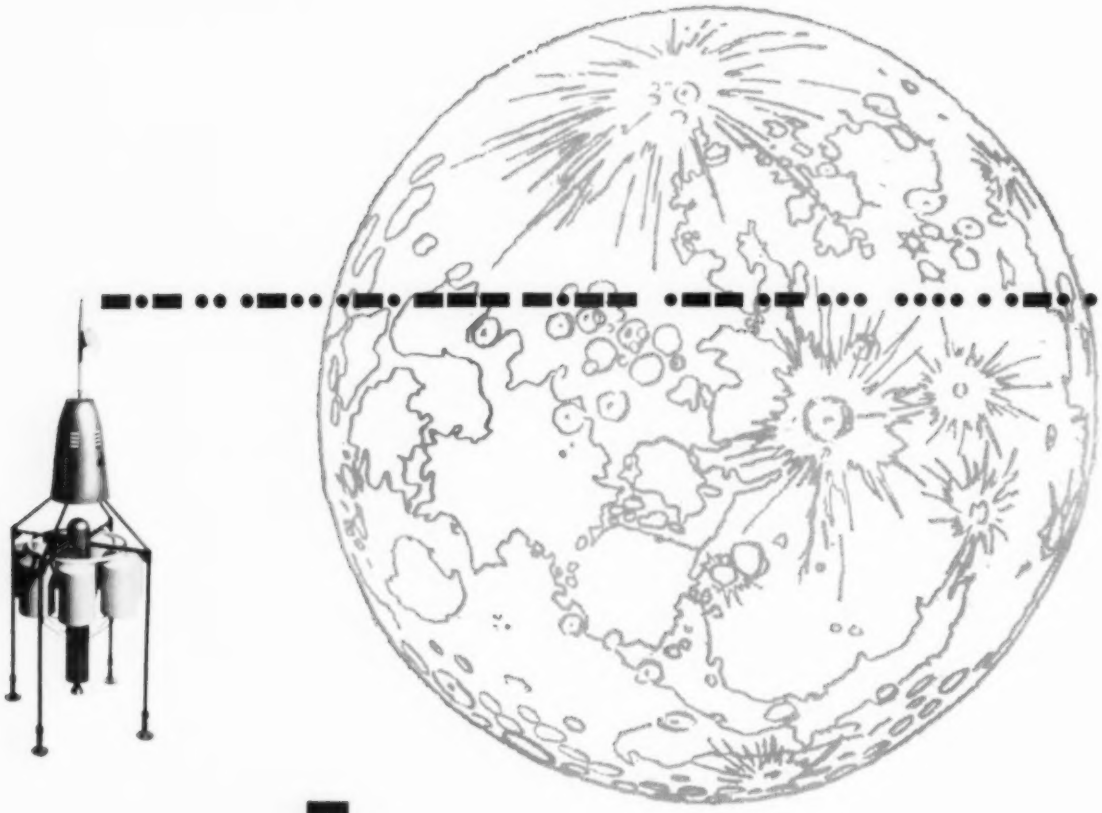
From Normandy to Eniwetok, P.F.C. Joseph Willie Kilroy was there . . . and he'll be out there somewhere when man in space is commonplace! Today, the top astroscientific and missile engineering teams in the country are already at work on the fundamental problems of space exploration and the manned orbit vehicle. One of those top teams is at Martin—with 30,000 engineering man-years of experience in missile and space system pioneering.



MARTIN
BALTIMORE · DENVER · ORLANDO

Necrology (Contd.)

Mr. Mitchell was born in Cincinnati. He was educated at Hughes High School and the University of Cincinnati. He started his business career in the publishing field, first with the Hearst publications in New York, Boston, Detroit, and Cleveland. In 1917 he organized the Steel Forgings Company in Cincinnati and five years later organized the Mitchell Steel Company.

He was a director of many industrial and philanthropic organizations. Among the former were Armco Steel Company, Central Trust Company of Cincinnati, Lunkenheimer Company, Eagle-Picher Company, and the Yale and Towne Manufacturing Company.

The Ordnance Association records with deep regret the passing of this valued and kindly member who contributed in great measure to its success and to the advancement of armament preparedness in peace and war.

• **JOHN H. CHAPLIN,** chairman of the board of Veeder-Root, Inc., Hartford, Conn., and a leading figure in business and industrial circles in Connecticut, died after a short illness while at his summer home in Nova Scotia on August 15, 1958. Long a member of the American Ordnance Association, he was, at the time of his death, a vice-president of the Association's Hartford-Springfield Post.

Born in Georgetown, Mass., he attended Phillips Andover Academy and was graduated from the Sheffield Scientific School of Yale University. He joined the Root Company in Bristol in 1917, following positions with Bethlehem Steel and the New York, New Haven & Hartford Railroad. The Root Company was merged with the Veeder Manufacturing Company in 1928, and a year later he was made secretary and sales manager of the new company.

Three years later he became vice-president and was elected to the board of directors. He was named executive vice-president in 1942, president in 1944, and chairman of the board in 1954. He also was a member of the board of directors of a number of other corporations.

He was very active in civic and professional organizations in Hartford and Connecticut and received several awards in recognition of his service.

A former president of the Manufacturers Association of Hartford County, Mr. Chaplin was a director of the National Association of Manufacturers, as well as one-time chairman of NAM's Industrial Health and Safety Committee. He was a member also of the Economic Club of New York, the Hartford Club, the Yale Club of New York, Newcomen Society of North America, and the American Society of Mechanical Engineers.

EXPERIENCE IN ORDNANCE WORK

Here are some of the Ordnance items produced by Aetna-Standard over the years...

Gun Mounts	Leveling Sockets
Gun Carriages	Axle Bearings
Howitzer Carriages	Nozzle Plugs
Drill Guns	Traversing Mechanisms
Pilot Models	Bogie Hubs
Breech Rings	Rocket Cases and Launchers
Navy Yokes	Landing Mat Machines
15" H. C. Projectiles	Fork Lift Trucks
Shell Crimpers	Half-Track Carriages
Firing Mechanisms	Skysweepers

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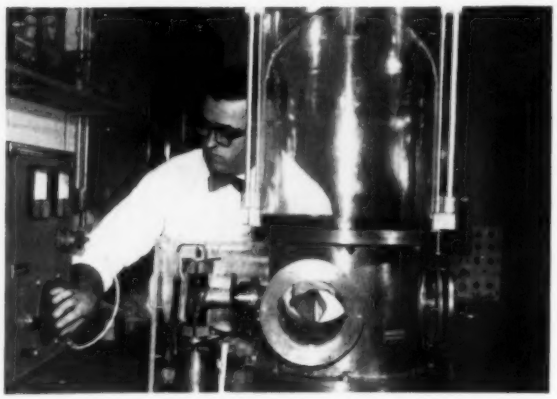
NEW DEVELOPMENTS

Plasma Accelerator

Possibilities for space travel were given a boost recently when General Electric unveiled a working model of what it calls a "pulsed plasma accelerator" which can be used to control the direction of space craft in flight using the magnetohydrodynamic principle to propel a low-density gas at high specific impulses.

Inside a T-shaped glass tube, with its normally horizontal cross-arm in a vertical position and the vertical arm extending



Working model of pulsed plasma accelerator.

into an evacuated chamber, a plasma is formed and discharged into the chamber. The plasma, composed of ionized gas, is produced by a hot electric field generated by regularly occurring sparks between brass electrodes. The current is returned through a brass strap outside the glass tube, setting up a magnetic field to help propel the plasma out of the tube into the chamber.

The evacuated chamber, designed to approximate the vacuum conditions of outer space, is produced in a bell jar. Inside the chamber is a paddle wheel that is propelled by the thrust of the plasma accelerator. The model accelerator produces a thrust of three-tenths of an ounce, sufficient to change the direction of a space craft in the near-perfect vacuum of outer space. Larger models are being developed.

High-Power Rocket Engine

The Advanced Research Projects Agency of the Department of Defense has assigned a high-priority project for the construction of a large liquid-propellant booster to the Army Ballistic Missile Agency, an element of the Army Ordnance Missile Command at Redstone Arsenal.

With a capacity of approximately 1,500,000 pounds of thrust, the new propulsion unit will have a thrust range about 8 times greater than the Nation's largest existing propulsion unit. The booster will consist of a cluster of currently tested rocket motors, packaged into a single unit according to proven engineering concepts. The main element of this cluster will be a motor similar to that used in the intermediate- and intercontinental-range ballistic missiles of the U. S.—the Jupiter, Thor, and Atlas.

This approach to development of a superbooster through the combination of existing motors is considered the quickest and

WHY CAN THE D8 HANDLE LOADS LIKE THIS?

One important reason is the design of the bulldozer blade. This powerful CAT D8 Tractor is equipped with the 17′ Balderson U Bulldozer, made exclusively for Caterpillar-built Tractors.

Note how the load of coal flows inward and forward, builds to huge size. The Balderson U Bulldozer is scientifically designed to keep loads like this rolling efficiently. When it's backed up with the 191 HP (flywheel) of the D8, the result is high production.

The Indiana & Michigan Electric Co. is using this Caterpillar D8 Tractor to push coal into hoppers for transfer to the power plant at Mishawaka, Ind. Three other D8s are also at work for the firm—and at low operating costs.

There are two big reasons why costs stay down with the D8—long work life and minimum down time on the job. For example, the D8 operates on such low-cost fuels as No. 2 furnace oil without fouling. Effective seals and filters protect running gear. The exclusive Caterpillar oil clutch needs no adjustment for thousands of hours, far longer than ordinary clutches.

Let your Caterpillar Dealer show you today how the D8 Tractor can give you more efficient coal handling. He'll bring one right out to your operation for a demonstration. And as a Caterpillar customer, you're sure of prompt service and quality parts to keep your investment paying off.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR

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THE NO. 1
COAL HANDLING TEAM

least expensive means of obtaining a propulsion system for placing very large payloads into orbit.

The Army work on the cluster will be carried out under the technical supervision of ABMA which has just placed a contract for $2 million with North American Aviation, Incorporated whose Rocketdyne Division will supply the propulsion elements.

New Small Arms

The Army recently announced that it has received Defense Department approval for quantity production of the new M14 ("Springfield") rifle and the M60 machine gun. Dollar value of the two programs amounts to approximately $35,000,000. A total of 70,000 rifles involving approximately $20,000,000 has been authorized in the present fiscal year 1959 budget.

To prepare for mass commercial production of the new M14 rifle, a pilot line has been established at the Springfield Armory with the first production item scheduled to come off the assembly line in June 1959. The currently authorized pilot-line run at the Amory will be 15,600 rifles at a cost of approximately $3,000,000.

Additionally, the Army has been authorized to produce from the fiscal 1959 budget 8,835 M60 machine guns at an approximate cost of $15,000,000. Of this amount, 5,835 will be produced commercially, while the remainder will be built at Springfield Armory to provide continuity of pilot-line production.

Navy F8U-2 Fighter

The Chance Vought Crusader II, scheduled to be the Navy's top performance fighter in the months ahead, is now in production. Although performance details are classified, it has been disclosed that the new plane flies at nearly twice the speed of sound. It has the same lines and same dimensions as the F8U-1, except that two fixed fins have been added under the tail section and two small afterburner airscoops have been mounted atop the tail cone. The ventral fins provide increased stability at the higher speeds at which the F8U-2 operates.

The Crusader III, currently undergoing tests at Edwards Air Force Base, Calif., is an example of the Navy fighter of the future (see photo on page 398).

Armament on the F8U-2 consists of Sidewinder air-to-air guided missiles, four 20-mm. cannon, and thirty-two 2.75-inch rockets. It also has a 2-position wing which enables the fighter to achieve very high speeds and yet land on the small area of carrier deck.

Air Force Studies Rays

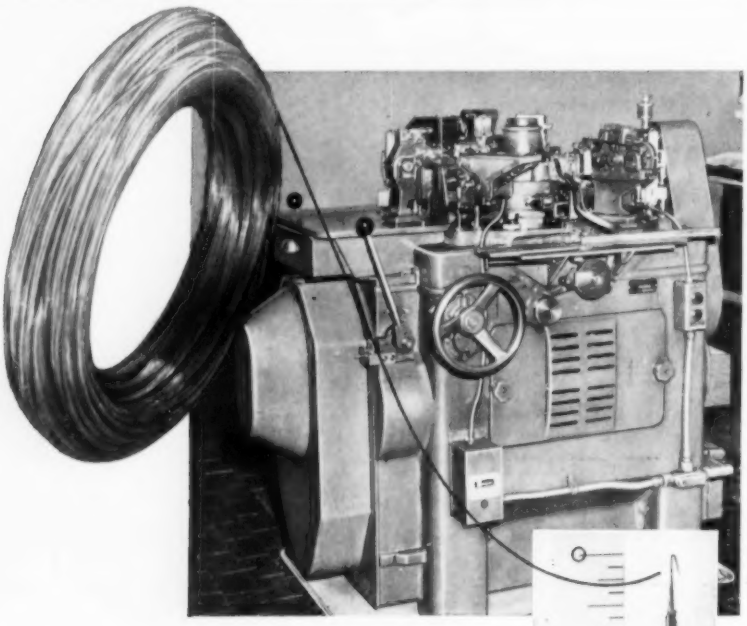
The possibility that infrared and ultraviolet rays will prove valuable in tracking targets at high altitudes was revealed recently. To perfect guidance systems that follow a path directly to targets, Air Research and Development Command scientists assigned to Wright Air Development Center, Dayton, Ohio, are studying results of a series of high-altitude tests at the Air Force Missile Development Center, Holloman Air Force Base, N. Mex.

The tests consist of measurements of infrared and ultraviolet rays taken from balloon flights as high as sixteen miles above the earth's surface. Carrying a 500-pound gondola, each balloon measures 93 feet across when it reaches an altitude of 80,000 feet. The equipment aboard the gondola includes a scanning device which consists of a reflecting mirror-scope similar to the reflecting telescope used by astronomers when star gazing. This device makes a 180-degree turn, gathering information on infrared and ultraviolet rays.

New Personnel Carrier

Large Army combat vehicles will soon be transported on an experimental basis by air direct from manufacturer to their

(Continued on p. 443)



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Engineering • Tooling • Modern Machine Shops • Precision Assembly
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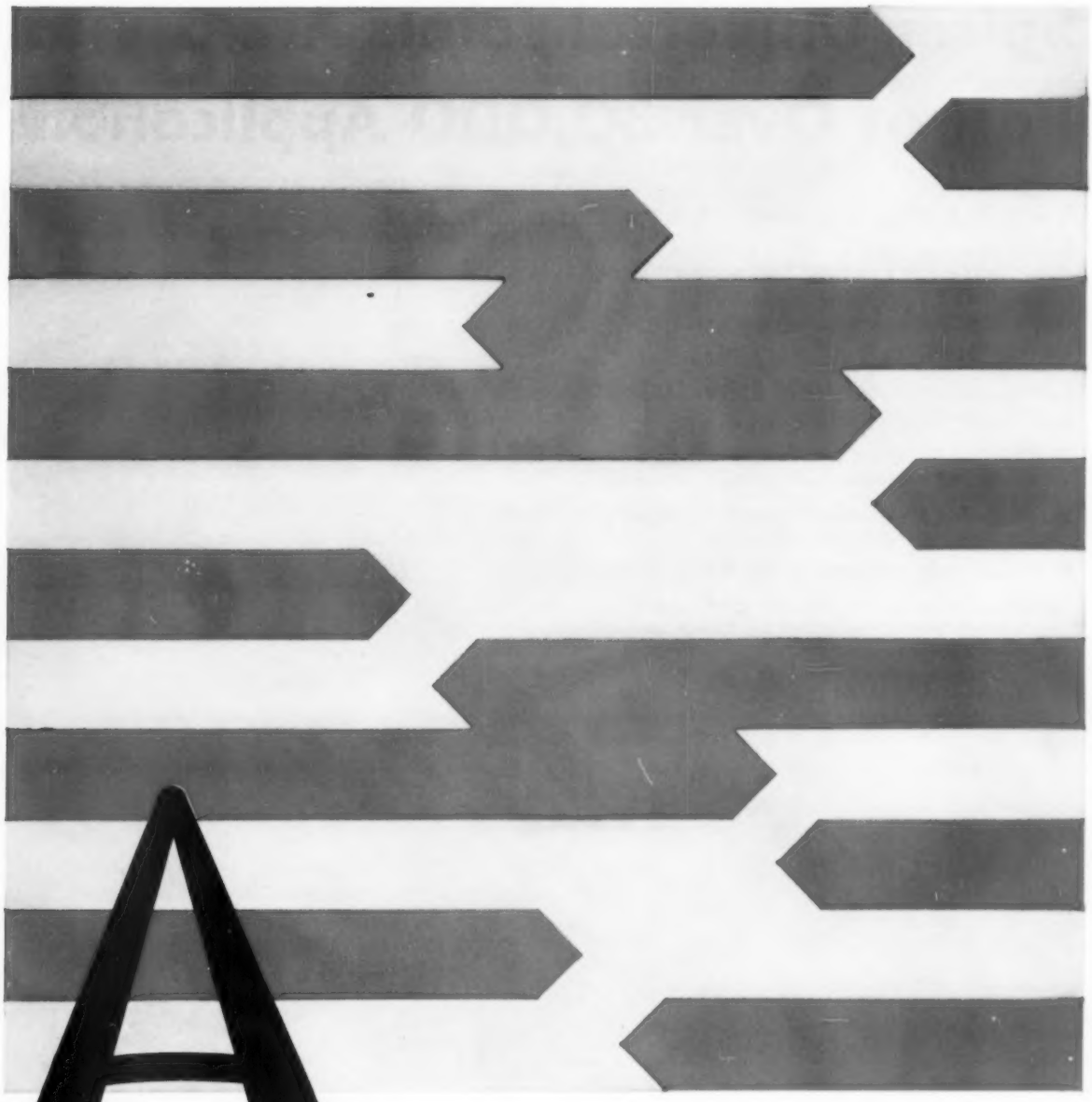

ASTRODYNE —aimed for the future in solid rocketry

Astrodyne was founded early this year to bring together in one productive group all the skills, experience, and facilities it takes to design and manufacture America's major solid propellant missile systems.

From Phillips Petroleum Company came men with impressive backgrounds in research, design, and manufacture of superior solid propellants. From North American Aviation came men who know missile systems management, and who have designed and built the largest rocket engines in use today.

Today Astrodyne has the experience to design, develop, and manufacture complete propulsion systems, extruded and cast propellants, solid propellant rocket motors and boosters, and gas generator charges for auxiliary power units.

Inquiries are welcomed on any phase of the solid propellant field—from preliminary design to quantity production.

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You'll find Spicer Universal Joints specified on all kinds of aircraft . . . *where quality must be the highest* . . . on dynamometers . . . *where dynamic balance is critical* . . . on off-highway equipment . . . *where dirt is the thickest.* In all, designers have employed Spicer Universal Joints in over 30,000 ways.

Compare these features of Spicer Universal Joints before you write your specifications:

- **Case hardened splines are ground to a smooth finish on all sliding surfaces, then phosphate coated.**
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DANA PRODUCTS Serve Many Fields:

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AVIATION: Universal Joints, Propeller Shafts, Axles, Gears, Forgings, Stampings.

RAILROAD: Transmissions, Universal Joints, Propeller Shafts, Generator Drives, Rail Car Drives, Pressed Steel Parts, Traction Motor Drives, Forgings, Stampings.

AGRICULTURE: Universal Joints, Propeller Shafts, Axles, Power Take Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

MARINE: Universal Joints, Propeller Shafts, Gear Boxes, Forgings, Stampings.

Many of these products manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario.

destination at Army establishments throughout the continental United States and Alaska.

The 13-man vehicles, being transported by the Military Air Transport Service, are armored personnel carriers (T113) made of aluminum. Each T113 can mount a caliber .30 or caliber .50 machine gun. The manufacturer is the Food Machinery and Chemical Corporation of San Jose, Calif. The aluminum structure provides equivalent ballistic protection with less weight than comparable steel covering.

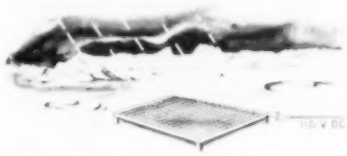
The amphibious vehicles are pilot models for test by Army Ordnance and the U. S. Continental Army Command. While the T113 was designed primarily to provide the Infantry with armor-protected battlefield mobility, it also can be used as a rocket-launcher carrier, a self-propelled weapons carrier, a mortar carrier, an anti-tank missile carrier, ambulance, communications vehicle, command post vehicle, cargo carrier, or fire-direction center.

Mach 4 Missile

The Air Force recently disclosed that a Lockheed X-7 ramjet missile had been flown in excess of four times the speed of sound to become the fastest air-breathing missile in the free world. The bird was developed for the Air Force to flight-prove huge and powerful ramjet engines which will power some of the Nation's defensive missiles.

Lunar Power Station

Elements of an electric power station using light from the sun but designed for use on the moon were demonstrated recently by scientists at the Westinghouse Electric Corporation. The importance of a lunar electric power plant is dictated by the fact that a United States space base on the moon must, first of all, be entirely self-sufficient.



"Electronic farming" for moon power

Power output: 1,200 kw. per acre
Weight: 1.7 lbs. per kw.
Capital cost: $3.50 per kw.

The moon power station will use only wire mesh and a chemically coated plastic as its basic components. Giant sheets of a thin plastic material, similar to that which supermarkets use to wrap vegetables, will be stretched and supported over several acres of the moon's surface. The plastic will be coated with a special light-sensitive chemical.

After the plastic is in place, a thin wire mesh, much like window screening, will be placed parallel to the plastic. It will be slightly separated from the plastic and insulated from it.

As the rays of the sun strike the plastic sheet, the chemically treated surface will emit electrons which, in turn, will be collected by the wire mesh. This process creates an electric voltage which will exist as long as the sun shines on the surface, which can be called an "electron farm." The total weight of required materials would amount only to about 2 pounds per kilowatt, and the station would operate with an efficiency of about 25 per cent compared with 35 per cent efficiency of the conventional earth-bound generating station. Additional work is expected to raise the efficiency of the lunar power plant.

High-Speed Propeller

The Navy has developed a new "super-cavitating" propeller which it is believed will greatly increase the speed of naval vessels. Submarines and hydrofoil craft may attain speeds of over 200 miles an hour while more conventional ships may make up to 80 miles an hour. However

HERE ARE A FEW EXAMPLES OF THE PROBLEMS WE ARE PREPARED TO SOLVE:

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- ☐ Report Making
- ☐ Liquid flow analysis
- ☐ Power utility distribution studies
- ☐ Computer simulation
- ☐ Cut and fill calculations for highway construction
- ☐ Engine design calculation
- ☐ Vibration analysis
- ☐ Military and management consultation and operations analysis
- ☐ Automatic structures design programming
- ☐ Mathematical or scientific equation and problem solving
- ☐ Product or organization simulation
- ☐ Other (please describe)

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CPA 10

only those vessels designed for such speeds will be able to use the new propeller.

The new "wheel," a single spiral rather than a 3-bladed device, does not attempt to eliminate cavitation—the formation of bubbles or cavities that act as a drag on a conventional propeller. Instead it gets all its thrust on the after part of the blade so the cavitation on the forward part is neutralized.

Algae for Spacemen

Photosynthesis, which replenishes life-sustaining oxygen in an endless cycle on earth, may enable man to travel in outer space and under the oceans for unlimited periods of time, it was reported recently at the first international symposium on submarine and space medicine.

The feasibility of growing algae in nuclear submarines and space ships was outlined by T. A. Gaucher of General Dynamics Corporation's Electric Boat Division, who announced that a new strain of algae has been developed which increases 1,000 times a day compared with only 8 times a day with previously employed algae.

The noxious carbon dioxide respirated by men is removed from the closed atmosphere of sealed containers by the algae which in turn produce oxygen in the same manner that green plants do on earth. In addition, the report stated that the algae also produce large quantities of highly nutritious food material (*e.g.*, proteins and vitamins).

Parachute Tests

Plans to test parachutes at speeds of more than 3,000 miles an hour and at altitudes of 26 miles above the earth have been scheduled by the U. S. Air Force. Tests will be conducted with a new rocket test missile nicknamed the "Cree." The missile will enable engineers and scientists to study the performance of first-stage parachutes for manned aircraft escape capsules, missiles, and drones.

Tests will be conducted at altitudes between 30,000 and 150,000 feet and at speeds from 1,520 to 3,040 m.p.h.

The Cree features a cluster of three test missiles mounted parallel and propelled by a ground-to-air missile booster unit.

At a preset time, or by ground control, the missiles separate and travel independently, about thirty feet apart.

At this point, timing mechanisms set off the parachutes which eject backward from the three missiles. Cameras, focusing through the tails of the missiles (and facing the parachutes) then start recording the actions of the open 'chutes.

Timing mechanisms later deploy 12-foot parachutes, lowering the units gently to the ground. During the entire flight, performance information is relayed to ground personnel by telemetry.

Mine-Clearing Snake

An improved version of the World War II mine-clearing "Snake" is being developed by the U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., and is currently undergoing tests by troops in the field. This new model consists of a series of prefabricated, quickly connected sections that can be assembled in less time than its predecessor.

Sections of the Snake are transported by truck to an assembly point. After assembly, the unit is towed by tank to a mine field where it is pushed over the field and detonated to clear the area of mines. One complete Snake is 400 feet long.

The new device utilizes specially designed charges in place of the conventional charge of the old model, resulting in improved mine-clearing performance with less explosive.

Nuclear-Powered Frigate

A new nuclear-powered guided-missile frigate will be designed and built by the Bethlehem Steel Company, Quincy, Mass. The new ship will have a much greater cruising range at sustained high speeds than conventionally powered frigates.

She will have twin Terrier missiles mounted fore and aft in addition to anti-submarine weapons and conventional armament. The DLG(N) will be 550 feet long, have a beam of 56 feet and displace 7,600 tons. The only other nuclear-powered surface ship authorized at present is the attack carrier U.S.S. ENTERPRISE, now being built.

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HIGH SPEED PRESSES
Two Post Blanking
Four Post Blanking
MULTIPLE STATION MACHINES
Cam Eyelet
Crank Eyelet
Multiple Plunger
Pillar Presses
Transfer Presses
Horizontal
Redraw Presses
OPEN BACK PRESSES
Double Acting Cam
Double Acting Crank
Geared
Single Acting Crank
PILLAR PRESSES
Double Acting Cam
Double Acting Crank
Geared Pillar
Single Acting Crank
SMALL PRESSES
Foot
Hand
Safety Bench
Single Acting
Open Back Bench
SINGLE AND DOUBLE GEARED ARCH DRAWING PRESSES
THREADERS
Inclined Shell Threaders
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Waterbury Farrel's extraordinary range of press-building experience encompasses a wide variety of single and multiple operation presses. These include virtually every commercial type up to 600 ton capacity. In addition, Waterbury Farrel has successfully engineered automated press output by combining presses, feeds, hoppers, straighteners, coil holders, scrap choppers, scrap winders, finger motions, attachments for side piercing, blank turning, stripper release, and blank holding mechanisms into production-team units.
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Vought Vocabulary

re·li′a·bil′i·ty: *Fleet-proved heritage of Crusader III, backed by 41-year Chance Vought tradition*

Reliability, like superior speed, altitude and maneuverability, is built into Vought missiles and aircraft. This vital ingredient is the Fleet-proved heritage of *Crusader III,* Chance Vought's automated all-weather Navy fighter.

Crusader I achieved a major breakthrough when it became the first 1,000-mph-plus fighter to operate from aircraft carriers. This airplane established U. S. and world records . . . became operational faster than any modern jet in history. In an era of increasing technical complexities, it is proving its reliability aboard Navy carriers in two oceans.

Regulus I became an *operational* missile as early as 1955. It has proved its reliability with a record of more than *700 flights. Regulus II,* carrying on this tradition for reliability, in September accomplished history's first flight of a supersonic missile from a submarine.

Experience gained with *Crusader I* and the *Regulus* missiles is the heritage of *Crusader III* — a heritage backed by 41 years of developing, producing and servicing *reliable* sea-going weapons.

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Crusader I on duty with the Fleet.

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For Safe, Leakproof Shut-off of Liquid Fuels

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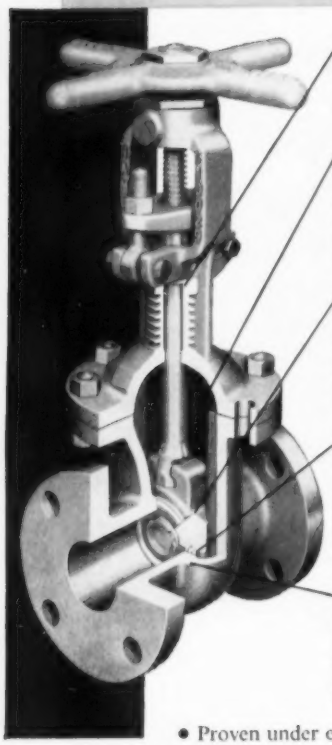

Chevron Packing
Expands as pressure increases to prevent escapage at stem.

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Seal on one side vents chest to pipeline, thus preventing locked-in pressure buildups.

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Seating surfaces are precision finished for exacting metal to metal fit against seats.

Positive Shutoff Seal
Located in one side of the wedge only, this seal compresses against valve seat forming an absolute shut-off.

Integral Body Seat
Integral design eliminates threads, welds & other objectionable surface irregularities.

• Proven under environmental field conditions, these contour engineered Gate Valves seal equally well with line flow in either direction. Seal in one side of wedge vents valve chest to pipeline preventing dangerous pressure buildup. Valves are available in various sizes in a range of metals. Write today for literature and the name of your nearest Hamer representative.

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MATERIALS PROGRESS

George S. Brady

Oil from Shale.—Despite the fact that there has been a domestic surplus of petroleum, the precarious future supply situation enshrouding Middle East oil has enlivened interest at managerial levels in shale oil development. In a concentrated area of northwestern Colorado, Utah, and Wyoming lies what is undoubtedly the largest oil supply in the world, possibly exceeding all known petroleum reserves.

For economic reasons of present oversupply, one company which has been working on Colorado oil shale since 1955 stopped production in August and shifted operations to a program of research for lower-cost methods. Nevertheless, technical men of this company have stated that in case of war or the cutting off of foreign supplies, research is so far advanced that quantity production could be initiated as quickly as adequate facilities could be erected.

The Bureau of Mines ceased production of shale oil when private companies came into the field because it is not the present intent of the Government to compete in commercial production of oil. But the Bureau has continued its research, and in the fourteen years of its intensive work it has done a remarkable job in the development of techniques of mining the shale, retorting, refining, and in the study of transport.

The Denver Research Institute has estimated that more than 2,000 retort designs have been tried out here and in Europe, but that the two simple designs recently employed in Colorado pilot plants, heated by recycled gases, are well advanced for low-cost quantity production.

It was shown as early as 1955 that oil from Colorado shale could be delivered on the West Coast at costs under those for West Coast petroleum. No less than eighteen companies now have acreage holdings in the Colorado oil-shale area in addition to the naval oil reserve where the Bureau of Mines has been working. Pipelines to distribute the oil products have been projected, and it has been indicated that the cost of transporting oil from Colorado to Chicago by pipeline would be only 28 per cent of the cost of sending it by railway tank car.

Official Government surveys indicate that at least 1,000 square miles of the 2,500-square-mile oil-shale area of northwest Colorado alone contain readily mineable shale of high quality. Allowing for a loss of 15 per cent in mining and only a 90 per cent oil recovery, and assuming a content figure below that already obtained in pilot plants, it has been estimated that this single field, with a continuous series of beds up to 500 feet thick, would yield 500 billion barrels of recoverable oil, or more than 300 years' supply at a production rate of 5 million barrels daily.

Other private surveys, covering the whole Colorado-Utah-Wyoming area, have indicated some fantastic production possibilities.

No oil is visible in the shale; it is present as the solid kerogen which yields oil when heated to about 900 degrees Fahrenheit. Some test specimens have shown as high as 90 gallons of oil per ton, but all cost estimates have been made on the basis of an average recovery of not more than 30 to 35 gallons per ton of

(Continued on p. 449)

Colonel Brady is a consulting engineer, author, and editor, Washington, D. C. He is a well-known authority in the field of materials, and his "Materials Handbook" is a recognized source of information on the subject.

EXTRUSION • CASTING • FORGING • FABRICATION

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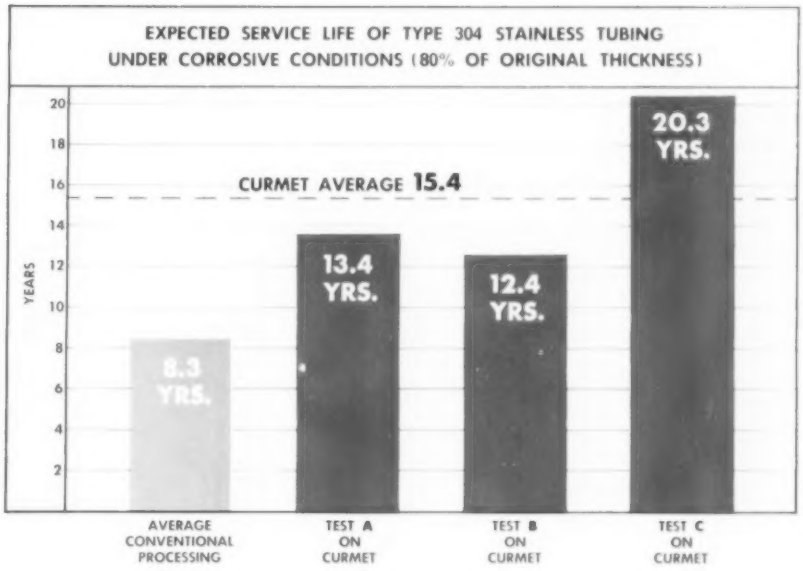
for new levels of Corrosion Resistance in standard stainless steels



Tests by three CURMET customers* confirm the findings of Curtiss-Wright's own Metals Processing Division laboratories: CURMET extrusion imparts substantially greater corrosion resistance to stainless steel alloys.

For the results shown graphically above, test samples of conventionally wrought and CURMET extruded material were subjected to the standard boiling nitric acid (Huey) test in accordance with ASTM specification A-262.

The tests were made in relation to requirements for nuclear power installations of tubing and fittings. The increased service life that can be expected with CURMET processed stainless is attributed to a homogeneous micro-structure not attained by other methods of conversion. It is achieved at no sacrifice in tensile strength, ductility, impact strength or other property affecting performance of the product.

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TELLING THE MISSILE WHERE TO GO

. . . and how to get there!

The button is pushed. The missile rises from the launching pad – slowly – then roars into space.

But the problem has just begun! Now the "brain" inside the missile takes over. This is the crucial part of missile warfare.

The target must be found – or met head-on – or overtaken. The missile must be *steered*. It must change course, double back if necessary. It must "think" its way to the enemy.

What ITT is doing about it

Since 1949, top scientists in ITT laboratories have been deeply engaged in missile guidance and control. They are deeply engaged now – playing a big role in national defense – working with the Navy, the Air Force, the Army, universities and associated laboratories, and other manufacturers.

They developed the complete airborne guidance for TALOS, the Navy's deadly "flying fish" launched from guided-missile cruisers. They developed the complete guidance for the Army's LACROSSE, including ground, air, tracking, and computing equipment. They helped with RASCAL, an Air Force air-to-surface missile. They developed the launching and firing controls and test equipment for the Air Force's BOMARC missile. They are designing and building communication networks for the ATLAS intercontinental ballistic missile.

Experience – where it counts

ITT is especially qualified for missile guidance development – because of long experience and special skills in air navigation and radar.

Other skills count heavily too – in infrared detection and homing, direction finders, inertial systems, computers, semi-conductors. ITT is also rich in these skills, and has the research laboratories and expanding manufacturing plants to carry the work forward.

Depend upon it – when the missile is launched, it will know where to go . . . and how to get there.

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shale. The Bureau of Mines reports that the flat, horizontal formations, which can be mined without artificial support, are unusually favorable for low-cost mining.

Gyratory crushers break the shale to a size of 1 to 3 inches for feeding into the continuous-action retorts. After removal of the oil, a part of the gas stream is recycled to the retort to serve as the heating fuel. Since the area is semiarid, methods have been developed that require little or no processing water. Both the ash and the oil stream are cold when they leave the retort, so that no external cooling is required.

The kerogen of the oil shale is a high-molecular-weight complex chemical material high in nitrogen (2.6 per cent) and high in sulphur (1.3 per cent). The resulting crude shale oil has a nitrogen content of 1.8 per cent and a sulphur content of 0.8 per cent. The oil is intermediate between crude petroleum and pyrolytic coal products, and it is stated to be well adapted to the manufacture of chemicals as well as to the production of jet fuels, motor gasolines, and other standard products. Technicians who have worked on analytical and refining processes in the area during the past decade visualize large-scale commercial by-products when oil production is established.

Direct by-products will be sulphur, ammonia, and coke in large quantities, but a wide range of chemicals can be produced readily. The spent shale can be used for the manufacture of cement, building blocks, and other products. Availability of water will be a factor in the location of such industries.

In the perspective of present world petroleum economics the forecast in the Paley Report of two million barrels' daily production of shale oil by 1975 seems entirely too conservative. There are motive factors in the political-economic situation today that were not apparent when the report was made. Moreover, since then it has been firmly established that shale oil can be delivered at costs lower than those for natural petroleum.

While Western shale oil may not at once be available to compete directly in Europe with Middle East oil, its development could release other petroleum to eliminate much of the dependence of Europe on the politically unstable Near East.

Electricity from the Sun.—A thermionic energy converter, for direct conversion of heat from solar rays into electrical energy, has been developed by the *RCA Laboratories*. The cell cathode is a ribbon of tungsten, and the anode is a barium-covered nickel, operating in a cesium vapor. The vapor is obtained in the tube by reduction of cesium dichromate, with sufficient cesium to yield a vapor pressure equal in equilibrium with liquid cesium for the range of ambient temperature used.

This converter acts as a constant-current generator. Efficiency is greatest at temperatures from 2,500 to 3,000 degrees Fahrenheit, and the concentrated heat can be furnished by parabolic-mirror solar furnaces. Neutral atoms striking the hot cathode are ionized and injected as positive ions into the interelectrode space, forming a plasma beam extending from the cathode to the anode. The voltages of 4.52 for tungsten and 3.89 for cesium give the necessary difference between the work function of the cathode and anode. The anode current is constant at about 2.5 volts, with 24 watts per unit.

Nuclear Fuel Elements.—*American Lava Corporation*, Chattanooga, Tenn., has a new plant to produce ceramic nuclear fuel elements in the form of cylinders, tubes, plates, and shapes. The urania and urania-thoria mixtures of various UO_2 enrichments are ball-milled and screened. These powders are compacted, hydraulically pressed, and fired at high temperature. Also to be produced are thermal neutron detection foils of dysprosium or gadolinium oxides dispersed in aluminum oxide.

Solar Battery Units.—*Hoffman Electronics Corporation*, Evanston, Ill., is now in commercial production of solar battery panel units. The stock unit, which will

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Here is a rocket-motor starting igniter engineered by Beckman & Whitley. Threads into the propellant chamber and withstands its pressure. Arms and disarms remotely, electrically; provides status signals, electrical and visual. How about one to your specifications?

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This tiny guillotine severs electrical or hydraulic lines explosively by electrical command signal, can be equipped with wide range of squib provisions —two examples are shown. Many specialized types with cutting diameters to 4 in. have been produced. What can we do for you?

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Acceleration-integration mechanisms in this Beckman & Whitley arming and firing device are in duplicate for ultimate reliability. Total arming time adjustable from 2 to 8 sec. Has automatic reset, electrical primer safety switching and return telemetering circuitry, is adjustable for acceleration in either direction. Other types include lanyard and electrical arm/disarm canister and primacord destructors. If your problem is different, let us hear from you.

Pre-packaged explosive power units provide higher reliability and greater power for a given weight and volume of space than any other actuation method. Some of the many other applications to valving, ejecting, fracturing, etc., may be interesting to you. Just ask us.

Beckman & Whitley INC., SAN CARLOS 1, CALIFORNIA

Materials Progress (Contd.)

give 5 watts at 6 volts, is a panel of aluminum, 12 by 20 inches, containing 144 silicon wafer cells. *Du Pont*, one of the pioneers in the production of silicon metal, is now setting up to produce a superpure grade under an English license by reducing the metal from a very pure grade of silane, SiH_4. *Merck & Company* also will produce ultrapure silicon metal by a new German process.

Electrical Contacts.—*Fansteel Metallurgical Corporation*, North Chicago, Ill., has a new method of producing efficient electrical contacts from rod stock, called Cor-Bond. The rods are usually of free-machining yellow brass with a core of coin silver, gold, palladium, or any special contact alloy. After machining the contact shape on a screw machine, the projecting core is upset to make the contact face. The upsetting operation hardens the contact alloy and gives a smooth surface. The method is particularly adapted for small contact parts for miniaturization.

Abrasive Material.—An ingenious new material to replace abrasive paper or cloth for "sanding" wood is the Dragon Skin produced by *Red Devil Tools*, Union, N. J. The material, which comes in rolls up to 4.25 inches wide and up to 1,600 feet in length for continuous belt operation, consists of steel sheet 0.004-inch thick with a hundred and fifty 0.036-inch holes per square inch so punched as to provide a 5-sided burr at each hole, giving 750 tiny cutting edges per square inch in a uniform pattern. The scraping action on wood is indistinguishable from the operation of sanding.

Sugar for Industry.—Probably the most politically ridden material in the world is sucrose, commonly known as sugar. All producing and consuming countries have laws and regulations governing its production and distribution. In wartime, because of its great value as a food, it is usually under strict control. For many years chemists have been pointing out that the sucrose molecule has unique characteristics that would make it a most useful industrial raw material if the supply were stable and not subject to political whims. Allyl sucrose, for example, is a good substitute for shellac for many uses.

Now, *Eastman Chemical Products, Inc.*, Kingsport, Tenn., is offering sucrose acetate isobutyrate as a plasticizer and extender for resin lacquers and coatings. It is a semisolid resin compatible with most synthetic resins, and it can replace half of the nitrocellulose of a lacquer. It will produce tough, flexible melt coatings. The material is made by the esterification of sucrose with acetic anhydride and iso-

From concept to countdown... Crosley

A missile is no better than its parts! And Crosley, working from "research to hardware," is designing and manufacturing improved component parts for missiles. Several of today's important missile programs rely upon Crosley because it offers:

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- Proven design capabilities along with extensive, low-cost manufacturing facilities—including stainless-steel contour honeycombing, metal bonding and chemical milling.
- Systems management that insures both speed and efficiency during every phase of a project.
- Experience. Crosley has and is proving itself on many projects, including some involving the *Falcon*, *Polaris* and *Titan* missiles; the MD-9 fire control system, research and development of the *Volscan* Air Traffic Control System, MPS-16 Height Finder Radar, missile and mortar fuzing, and structural components for missiles and supersonic aircraft.

Avco-Crosley Missile Capabilities

Complete facilities for research, development, and engineering design of: *nose cones, air frames, electronics control systems, telemetering, automatic test and support equipment, ground handling equipment and logistics.*

Production and manufacture of complete missile weapons.

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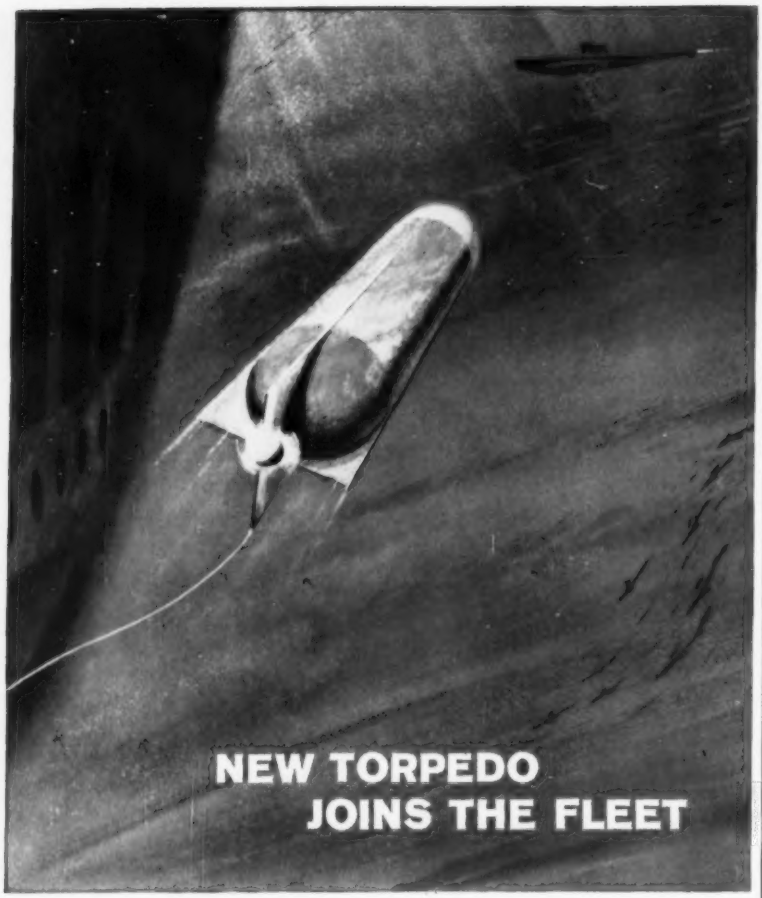
For further information, write to: Vice President, Defense Products Marketing, Crosley Division, Avco Manufacturing Corporation, Cincinnati 25, Ohio.



VITRO'S weapon systems capability is dramatically demonstrated in the new Mark 39, a wire-guided torpedo which the U. S. Navy has just added to our growing arsenal of underwater weapons.

Spider-like, the torpedo pays out a wire as it drives through the water. Over this wire combat crews send electrical signals that guide it to its target, regardless of course changes or other evasive actions. Swimming deep, Mark 39 leaves no telltale wake, generates no pulsations for detection, relentlessly closes on its target regardless of defensive maneuvers.

The wire technology, the torpedo, and the fire control system were developed into a weapon system for the Navy by Vitro Laboratories, a division of Vitro Corporation of America.

Complete weapon systems—for torpedoes, missiles, aircraft armament and acoustic detection devices—are taking shape at Vitro, one of America's most advanced corporations.

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- Recovery of rare metals and fine chemicals
- Aircraft components and ordnance systems
- Ceramic colors, pigments, and chemicals

Materials Progress (Contd.)

butyric anhydride. It has high molecular weight, 847, and a compact molecular structure that gives outstanding stability to light and heat. Since the melting temperature is about 350 degrees Fahrenheit, and the boiling point about 550 degrees, there is no fuming.

Aluminum in Automobiles.—After years of work, *Alcoa Research Laboratories* has produced an aluminum-fin, brass-tube automobile and truck radiator weighing 20 per cent less than conventional copper radiators and with material costs 20 per cent below those for copper units. Extensive tests have demonstrated a high efficiency of heat transfer and resistance to corrosion. Only recently Alcoa technicians demonstrated the superiority and weight-saving possibilities of aluminum-silicon alloy motor cylinder blocks over those of conventional iron castings.

With such new applications, and new uses in wheels, bumpers, and trim, a spectacular rise in the use of aluminum in automobiles and trucks may be anticipated. The automobile industry used almost one-third more aluminum in 1958 than in 1957, and its 1958 average consumption of 52.4 pounds per car is more than ten times the 1939 prewar car average. The increasing adoption of aluminum in cars has been on an efficiency basis, and not for cheapening. The 1958 Cadillac brougham, for example, contains 305 pounds of aluminum.

Lightweight Truck Trailer.—What is probably the lightest-weight heavy-duty flatbed truck trailer is being produced by the *Williamsen Body & Equipment Company*, Ogden, Utah, from aluminum. The trailer, weighing 7,400 pounds, is 2 tons lighter than a steel trailer and will carry 25 tons of concentrated payload. Two 21-ton tractors can be loaded on it. The extrusions used in the construction are of aluminum alloy 2014-T6. The eight disk wheels are of forged aluminum.

New Casting Alloys.—*Kaiser Aluminum Company* has a new aluminum-silicon-magnesium casting alloy made of high-purity materials. Designated Alloy X357, it has a tensile strength in permanent-mold castings of 52,000 pounds per square inch, with elongation of 5 per cent. The castings are characterized by good dimensional stability, machining properties, and corrosion resistance.

Several new aluminum-magnesium alloys have come into use in England. One alloy, adopted by a hardware manufacturer for hinges, handles, and plumbing fittings, has 10 to 12 per cent magnesium. It is corrosion-resistant, and has good wear qualities. Other casting alloys, with up to 8 per cent magnesium, also contain zinc and small amounts of manganese and

Here it is!

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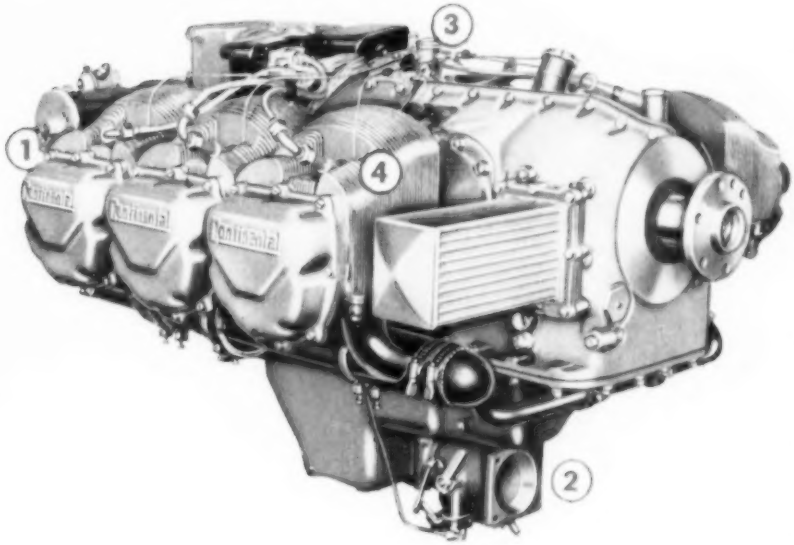
. . . the Greatest Aircraft Advance in Recent Years

CONTINENTAL CONTINUOUS-FLOW FUEL INJECTION

Continental Motors, power specialists since 1902, present the Continental Continuous-Flow Fuel Injection System as the greatest advance in its field in many, many years. Designed, developed, and built exclusively by Continental, and proved in well over a million miles of trouble-free flight, it brings an entirely new concept of performance, safety, dependability and economy to flying, vastly broadening the usefulness of airplanes.

FIRST REALLY SIMPLIFIED FUEL INJECTION . . .
no more running parts than carburetor fuel system! Very close tolerances eliminated — no plungers — nothing to get out of adjustment. It's as simple as this:



1. Conventional type fuel pump pressurizes fuel.
2. Metering valve linked to throttle regulates fuel flow. NO RUNNING PARTS.
3. Manifold valve divides fuel uniformly to all cylinders. NO RUNNING PARTS.
4. Nozzles discharge fuel into cylinder. NO MOVING PARTS.

Dramatic and convincing proof of the system's superiority is the world record distance flight of Capt. M. L. "Pat" Boling, from Manila, P.I., to Pendleton, Ore.—approximately 7,000 miles—in a current production Beechcraft Bonanza J35, on which Continental Continuous-Flow Fuel Injection is standard.

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YOU GET ALL THIS:

★ **SMOOTHER OPERATION,** because with the perfect fuel distribution which the system provides, power impulses from all cylinders are identical. Each cylinder does an equal share of the work.

★ **GREATER ECONOMY,** because with each cylinder getting exactly the same amount of fuel, all cylinders can be leaned out uniformly for better economy. Lean-out needn't stop, as with a carburetor, when the leanest cylinder begins to starve while others could be leaned still further.

★ **INCREASED RANGE,** because fuel consumption can now be predicted accurately. Gauge on instrument panel is calibrated to correlate injection system pressure with fuel consumption, in gallons per hour.

★ **HIGHER HORSEPOWER** with no change in engine displacement. The engine "breathes" freely, with the carburetor's restriction to air flow removed.

★ **BETTER ACCELERATION,** with none of the characteristic flat spots just above idle. Fuel doesn't have to travel from a distant carburetor, it's right at the cylinder all the time.

★ **FREEDOM FROM ICING.** The engine icing hazard is eliminated entirely, because the refrigerating effect of vaporizing fuel at the carburetor has been removed.

★ **REDUCED MAINTENANCE,** resulting from extreme simplification. (See cut.)

With Continental Fuel Injection, no carburetor heat is required—ever. You always use the coldest air available, for maximum power. Starting is fast and sure; accurately-controlled fuel metering to all cylinders takes care of that. Spark plugs last longer, too, because—thanks to uniform distribution of leaded fuel—all cylinders receive the same amount of lead.

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Materials Progress (Contd.)

copper, and, in one case, a small amount of nickel.

Tungsten Coatings.—A method of vapor spraying tungsten coatings on cold steel has been developed by the *Giannini Plasmadyne Corporation*, Santa Ana, Calif. Tungsten requires a very high temperature for vaporization, around 10,600 degrees Fahrenheit, but a high-velocity jet with a temperature far above this point is obtained from the energy of an electric arc on an ionized gas medium. The inert jet does not oxidize the deposited coating or the base metal, and a strong bond to the metal is obtained.

Molybdenum Deposition.—To obtain the anticorrosion and wear-resistant characteristics of molybdenum without the cost of the solid metal, *Climax Molybdenum Company*, a Division of American Metal Climax, Inc., has developed several new methods for deposition of molybdenum. A dense coating is obtained by vapor deposition of molybdenum pentachloride by reducing with hydrogen chloride. The pentachloride boils at 268 degrees centigrade so that vapors can be obtained above this temperature, but a temperature to 850 degrees centigrade is used for best results.

For lower-temperature coating, molybdenum hexacarbonyl with a carrier gas is passed over the parts to be coated at a temperature of 350 degrees centigrade, and a coating of molybdenum is deposited. Using this medium at higher temperatures, a coating of hard, wear-resistant molybdenum carbide can be deposited.

Carbon Filter Agent.—With its SGL carbon, *Pittsburgh Coke & Chemical Company*, Pittsburgh, Pa., has been demonstrating that an activated carbon made from coal can be more efficient for filtering gases and liquids than organic activated charcoals. The material is harder than organic charcoal and does not crumble into small particles. It has high density, 0.46, almost double that of conventional charcoal, and gives higher activity per unit weight. Its iodine number is about 1,000, compared with 650 for other carbons, and its index of color removal is about 40 per cent higher than ordinary activated carbon. Its greater purification efficiency thus permits faster rates of flow and cuts down equipment size.

New Rolling Mill.—*E. W. Bliss Company*, Canton, Ohio, has been working on a new rolling mill that will compact copper powder continuously and then feed it through a sintering furnace. Pilot-plant tests indicate that over-all cost of the powder-metallury strip copper, by savings in casting and rolling, will be lower than that of conventional copper strip.

Vibration and Shock

PROTECTION

for MISSILE GROUND SUPPORT EQUIPMENT

In the family of fine firms that serves the missile industry, there is one that is outstanding in its ability, attained through twenty-two years of experience, to assure performance and reliability for ground support equipment — Robinson Aviation, Inc. environmental control engineers.

Robinson all-metal mountings incorporate exclusive MET-L-FLEX resilient cushions. The non-linear spring rate and high inherent damping of these cushions make possible a variety of applications for the protection of ground support equipment from road shock and superimposed vibration during transit.

Typical of such successful production applications is a re-usable container incorporating a Robinson internal suspension system. This system, over a two year period, has demonstrated its effectiveness in protecting the inertial reference gyros of IRBM missiles during transportation from the laboratory to the launching site. Complementing this ground protection, twenty-four Robinson mounting systems protect the intricate mechanism of these missiles during launching and flight.

Through uncompromising loyalty to highest quality standards, reliability-minded missile experts are relying more and more on the *controlled environment* provided by Robinson MET-L-FLEX mountings.

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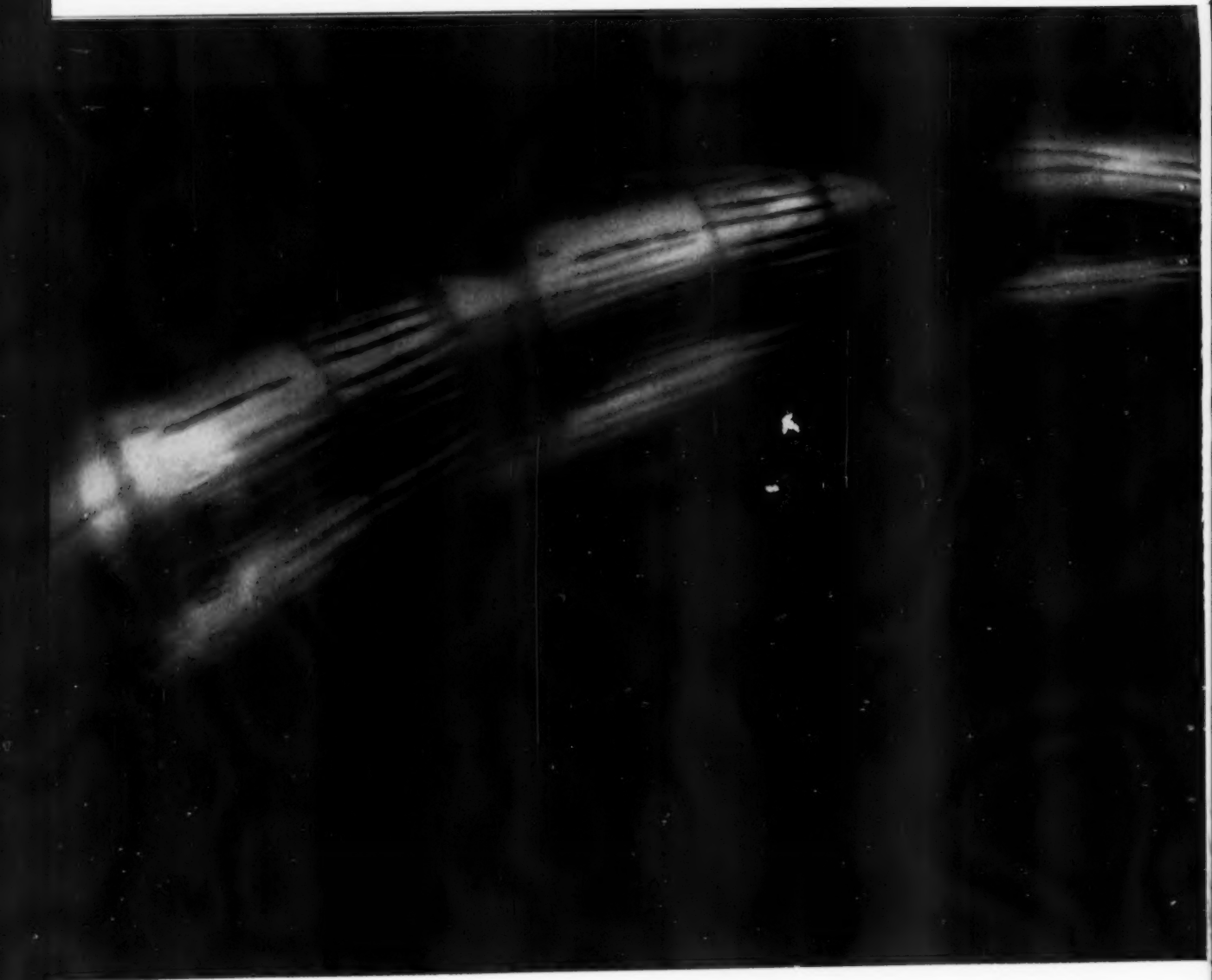
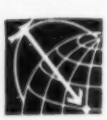


most of the missile is missing

Kearfott capabilities include:

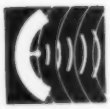


Inertial-guidance systems

Navigation systems

Gyros and gyro systems

Computers and components

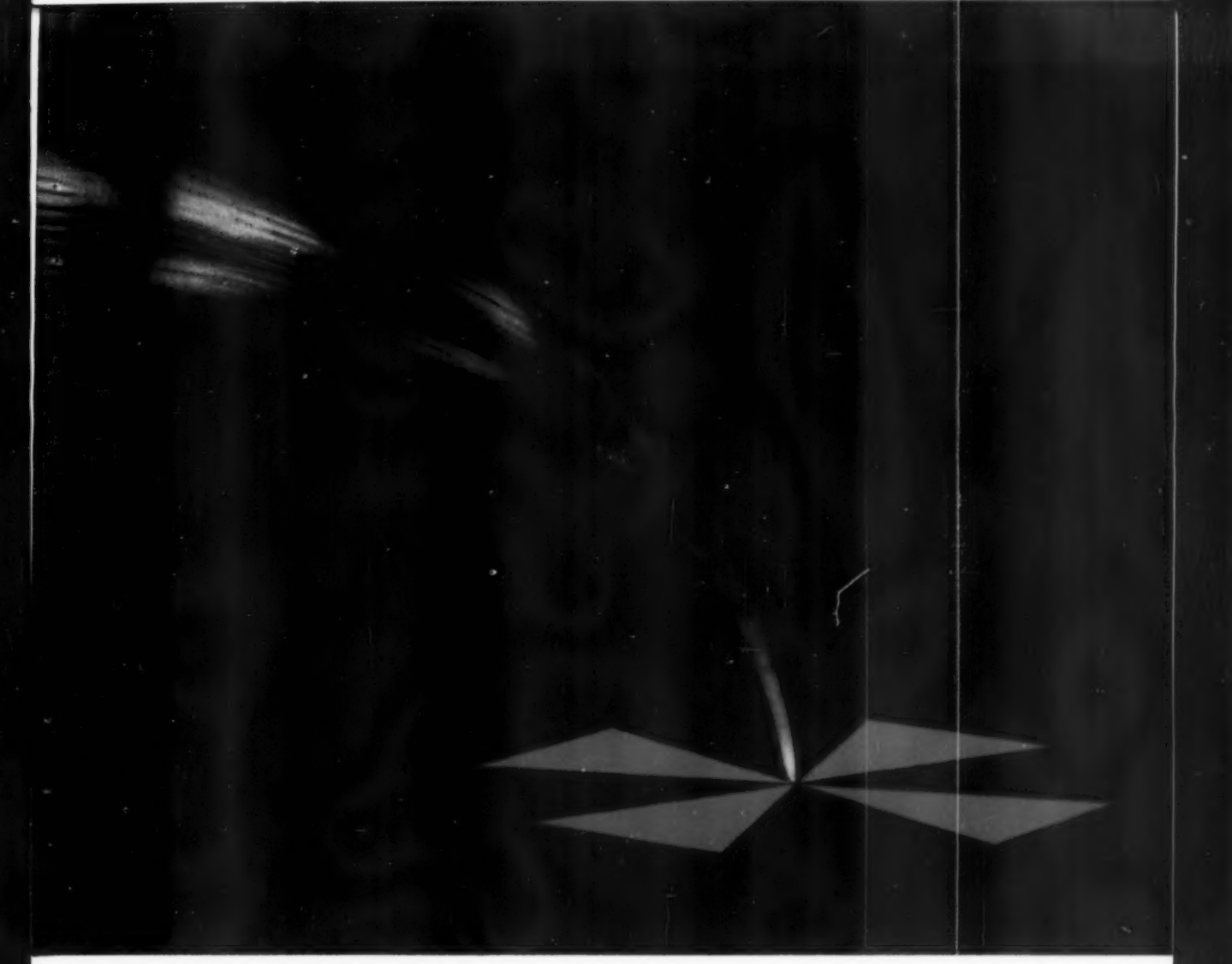


Radar

Ground support equipment

Test equipment

Control systems and components



. . . but the warhead is on target.

It was the missing stages, containing the precise guidance and complex control systems, that put the final stage accurately in its target trajectory.

Kearfott contributions to successful missile programs range from complete inertial-guidance and gyro systems, to the servos and computer mechanisms whose high reliability and performance have been tested under the most hostile environmental conditions.

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ROCKETS AND GUIDED MISSILES

Alfred J. Zaehringer

Missiles.—America's big line of missiles is moving toward operational status. At least two successful Atlas ICBM flights over the full 5,500-mile range have been reported. Previous Atlas tests had used only the two booster rockets for launching studies. The full-range tests used all three engines. The two booster rockets have a total thrust of 330,000 pounds while the single sustainer engine has a thrust of about 60,000 pounds—making a total of 390,000 pounds at launch. The sustainer engine is between the booster engines which are dropped after a few minutes. Control is provided by two oppositely placed vernier engines.

About two years behind Atlas in development is the Titan ICBM. The 5,500-mile-range Titan, unlike Atlas, is a 2-stage rocket. The first stage has two liquid rocket engines with a combined thrust of about 300,000 pounds. The second-stage rocket engine has a thrust of some 60,000 pounds. Designated SM-68, Titan uses liquid oxygen and JP-6 jet fuel. Gross weight is approximately 222,000 pounds.

Only the first-stage booster rockets thrust the missile upward on launch. When the first stage uses up all propellants, it drops off and the second stage fires. The Titan is believed more efficient than Atlas since it sheds considerable dead weight after launch.

Contracts have been awarded by the Air Force for work on the solid-propellant Minuteman ICBM. Minuteman is viewed as a 3-stage rocket. The upper stages will be similar to the Polaris and can be used as an IRBM. The Air Force Ballistic Missile Division will manage the Minuteman project.

Solid ICBM's will be relatively small, easily dispersed, have minimum maintenance, and will be ready to go on very short notice, achieving instantaneous retaliatory power.

Propulsion.—In the liquid-propellant field, three important trends have been noticed—development of more stable oxidizers than liquid oxygen, eventual application of more powerful oxidizers, and the increased use of newer fuels.

Liquid oxygen—with a boiling point of minus 297 degrees Fahrenheit—is the kingpin of oxidizers for all U. S. IRBM's and ICBM's now being tested. Such oxygen is not storable for any length of time. Since liquid rockets should be able to go at a few minutes notice, storable liquids must be sought, and two promising oxidizer replacements are being tested. The most advanced storable oxidizer undergoing test is nitrogen tetroxide.

This high-density liquid can be stored for long periods of time without great corrosion difficulties. Because of its high density, nitrogen tetroxide would give a range some 12 per cent greater than liquid oxygen in a V-2 type vehicle. It is believed that the Army may be planning to employ nitrogen tetroxide in such missiles as Redstone and Jupiter.

The second oxidizer is perchloryl fluoride. This fluorine oxidizer contains oxygen also and is storable under pressure for long periods of time. This oxidizer also is relatively noncorrosive. Nitrogen tetroxide has been produced in tonnage lots for some time while perchloryl fluoride is just now being made available in one-ton lots.

For applications that require the utmost in oxidizing potential, 100 per cent liquid fluorine is under test. Like liquid oxygen, liquid fluorine boils at minus 260 degrees Fahrenheit and cannot be stored for long. Its extremely high reactivity and toxicity requires very careful handling. In addition, fluorine combustion products usually are equally toxic.

However, liquid fluorine probably offers the tops in chemical propulsion. With alcohol as fuel, fluorine will give a performance of about 298 seconds while liquid oxygen will give some 240 seconds. A few fluorine combinations might get up to about 350 seconds, but above this, only atomic or free radical systems appear able to give higher rocket performance.

Not all oxidizers have proved successful, though. For the past decade, considerable research has gone into the preparation of one hundred per cent liquid ozone. Production methods have been successful, but the matter of stabilization remains the big problem. With fluorine at hand (despite the attendant handling and toxicity difficulties), the idea of using liquid ozone is fast fading.

Gradually, the old alcohol fuel is being replaced with newer and higher-energy combinations. Already the hydrocarbons—similar to the jet aircraft fuels—are being used as standard liquid missile fuels. Gasoline and kerosene blends have been used, but getting uniformity in composition and properties has been the big problem.

The big rocket engine is on its way. Wright Air Development Center has given North American Aviation a contract to build a million-pound-thrust liquid-propellant engine. Such an engine is equal to about three times the output of all three Atlas engines. The engine is designated as F-1. Not to be outdone, a large solid-propellant rocket engine recently was tested by the Army at Redstone Arsenal. The solid engine—believed to be a Nike-Zeus development—is said to have produced over 450,000 pounds of thrust—greater than that of any U. S. liquid engine now in existence.

Several approaches are being taken in the nuclear-propulsion area. One is an atomic rocket engine, another is an atomic ramjet, while a new entry is the use of an atomic explosion.

The atomic rocket—which will be tested late in 1958—is called Rover. The engine, strictly a ground-based atomic reactor, is called Kiwi A. It is believed that Kiwi will use the heat of the atomic reactor to expand a gas (probably hydrogen or helium) through a nozzle to form thrust.

Thrust output based on the entire propulsion system weight is expected to be inferior to present or future high-performance chemical rockets. The big reason for this inferiority is the necessary weight of radiation shielding; therefore it is probable that such atomic rockets will be used in space where weight is not so critical.

It is estimated by some that the atomic rocket, at its present state of development, would be able to perform at about the 400 to 600 seconds' range—or about double that of the best possible chemical combinations.

Another reactor, possibly using a liquid working fluid, has been called Dumbo. According to the Atomic Energy Commission it will not be tested until 1960.

Mr. Zaehringer, president of the American Rocket Company, Wyandotte, Mich., is a recognized authority on astronautics, guided missiles, and jet propulsion.

MISSILE GUIDANCE SYSTEMS

Projects of H. T. Budenbom,
Senior Scientist, Stavid Engineering, Inc.

Included in Mr. Budenbom's 25 patents and numerous technical papers are his original contributions in monopulse development and authorship of many new concepts in the application of electronics to modern warfare. His experience and inventive talents are being applied to Stavid's projects in weapon systems development and missile electronics. Mr. Budenbom is one of a group of outstanding scientists and engineers at Stavid who are working on advanced concepts . . . years ahead of actual systems development.

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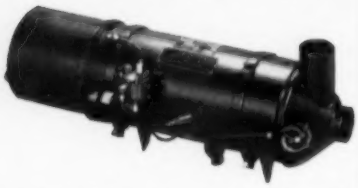

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HEATING AND REFRIGERATION SYSTEMS

SPACE ARMAMENT

Capt. Edwin E. Speaker, U.S.A.F.

Space Agency.—Two outstanding milestones of the recent congressional session were the passage of the President's Defense Reorganization Bill and the creation of the National Aëronautics and Space Administration. The intent of the Reorganization Bill is to eliminate interservice differences over missions and funds. Further, the new defense structure provides for more direct command "channels" from the Secretary of Defense to our land-sea-air forces in overseas theaters.

Nominated by President Eisenhower to be director of the NASA is Dr. T. Keith Glennan, president of Case Institute of Technology. The NASA will handle all nonmilitary space projects while military projects will remain under the Department of Defense.

Where Is Space?—The main question asked by House Select Committee on Astronautics has been, "Where does space begin?"

Dr. Hubertus Strughold suggests that "space" be defined as that point where the aërodynamic effects of the earth's atmosphere cease to be a major function. This occurs at an altitude of 120 to 140 miles. Final result is the usual attempt to establish a linear definition of space. A linear or geographic definition at first appears to be the most logical approach. It is similar to the conventional land-sea-air division of our armed forces.

Perhaps a more workable definition could be based on a kinematic fact true of all space vehicles rather than on the absence of aërodynamic forces. This is the existence of an additional force not normally considered in conventional aërodynamics. This force is, of course, the centrifugal force which is proportional to the square of the tangential velocity divided by the radius of arc (in this case earth's radius).

Simple mechanics express this centrifugal acceleration as V^2/R. If centrifugal accelerations of one per cent of local "g" were taken as a criterion then the required velocities at the earth's surface would be about 2,500 ft/sec. This velocity already has been exceeded on numerous occasions.

Both unmanned and manned vehicles have flown in this velocity regime. Air Force Chief of Staff Gen. Thomas D. White points out that Air Force operations and research have been "evolutionary" toward what is now referred to as "space flight." The evolution of vehicles that fly higher, faster, and for longer time periods has been the continual goal of the Air Force's technical program. Thus space represents merely a continuation of the Air Force's natural element.

This kinematic definition does not cover certain specialized vehicles such as very-high-altitude balloons or "sounding rockets" such as Aerobee and Farside. These vehicles have essentially a zero tangential velocity with respect to earth but nevertheless have been important tools for this country's upper-air and astronautics research program dating back to the end of World War II.

The definition of space is one of the major problems facing the policy makers in Washington.

Moon Shots.—Lunar probes are among the top priority projects under control of the Advanced Research Projects Agency. This Department of Defense office has directed that the Army undertake two probes and that the Air Force try three shots at the moon.

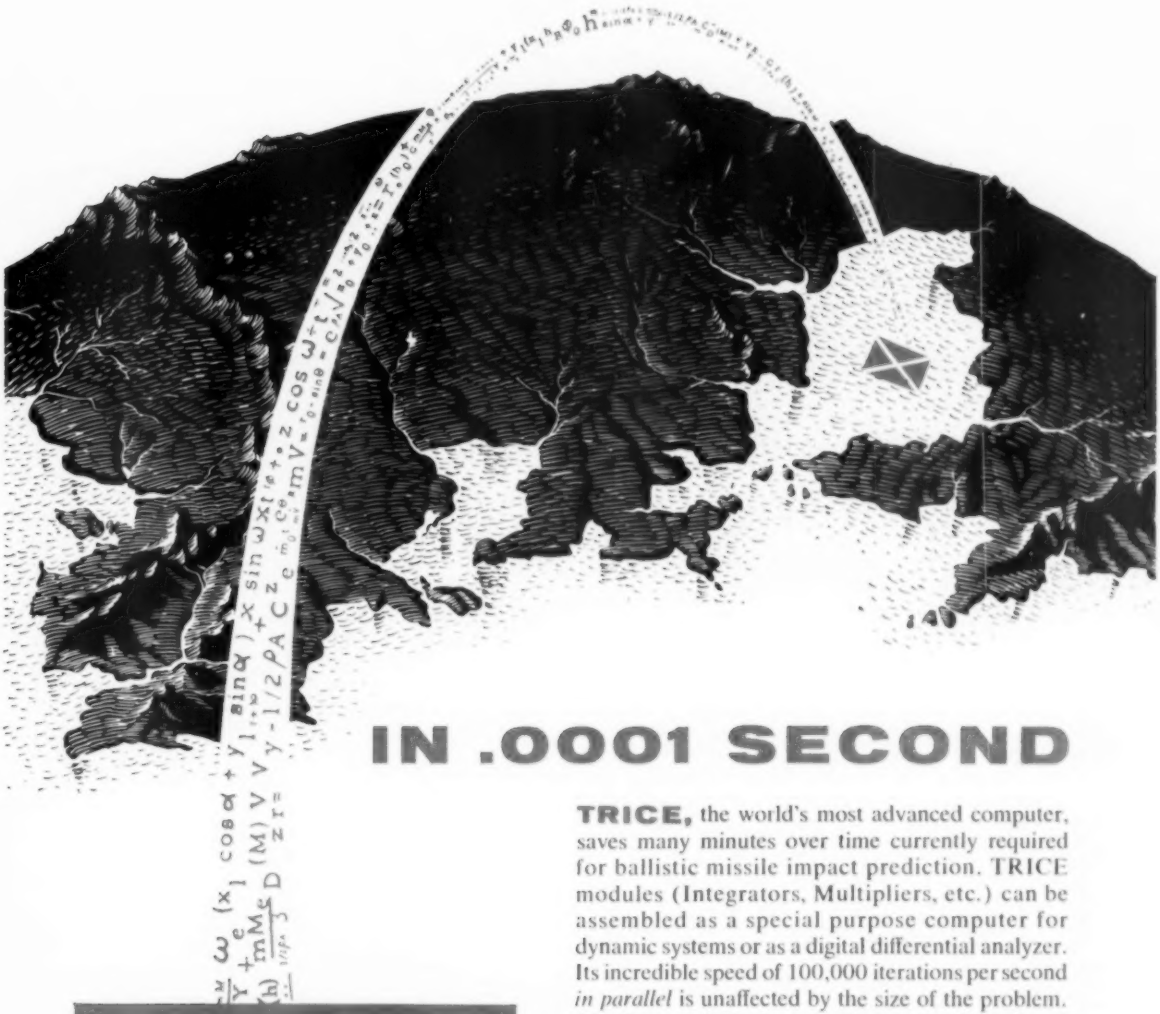
The first attempt at a lunar shot was by the Air Force in the middle of August. This attempt failed because of a malfunction in the Thor first stage.

Russian Satellite.—Sputnik III which was launched in May reportedly weighs over 2,900 pounds. This means one of two things: either the Soviets have developed huge rocket engines with thrust ratings over 250,000 pounds or they have successfully teamed several smaller engines, say three of 100,000 pounds' thrust each, into a reliable vehicle. In either case the Russians have clearly demonstrated a current superiority in large engine development. The next logical step for Ivan is manned space flight. Our own X-15 project (NAA-NACA-USAF) will not get off the ground this year.

Manned Spacecraft.—The X-15 will first be tested for North American Avia-

Captain Speaker is a graduate of the U. S. Naval Academy and M.I.T. and was formerly chief of the Falcon Missile Project Office at Holloman Air Force Base, N. Mex. He is now with Headquarters, Air Research and Development Command, Washington, D. C.

MISSILE IMPACT PREDICTION



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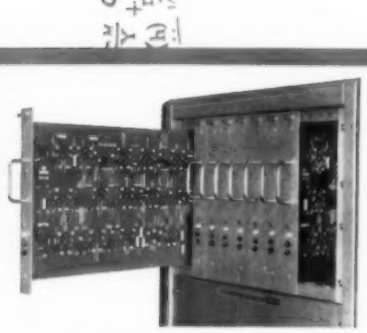

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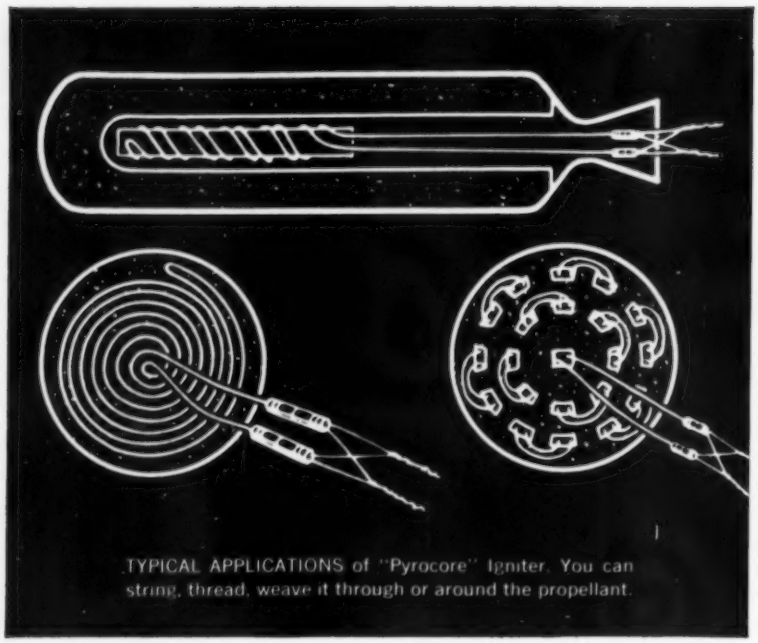

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Space Armament (Contd.)

tion by Scott Crossfield. Then, sometime in 1959, Capt. Robert M. White will fly the X-15 to an expected altitude of over 100 miles at a speed of about 3,600 miles an hour. A launch technique similar to the X-2 project will be used to get the X-15 airborne. A modified B-52 will carry the X-15 to its launch altitude over Wendover Air Force Base in Utah. The flight will end at the Flight Test Center at Edwards Air Force Base, Calif.

The primary purposes of the X-15 test program are to investigate effects of weightlessness, cosmic radiation, and reentry techniques. The X-15 will provide the basic data required for advanced weapons projects such as the Dynasoar, a rocket-boosted hypersonic glide bomber.

Of interest are the new subsystems being developed especially for the X-15. These include a 3-axis gyroscopic platform to provide an inertially stabilized reference for guidance and control purposes. A special electronic computer will handle altitude, velocity, and attitude data and will display this data to Captain White on advanced flight instruments.

Attitude control of the X-15 probably will depend on small jet nozzles located in the wing tips and fuselage. Expected high skin temperatures on the X-15 require that the entire cockpit be refrigerated.

Space Weapon System.—The Dynasoar vehicle will be the first manned space weapon system. This project is today barely into the proposal stage, although the idea was first conceived by Eugen Sänger as the "skip-glide bomber" thirty years ago. The new name, "Dynasoar," is a contraction of "dynamic soaring."

Sänger showed that a space vehicle could cover vast distances around the earth by "skipping" from regions of dense atmosphere into regions of negligible aerodynamic drag, much like a stone which can be made to skip across the surface of water. A trajectory of this type would indeed provide an exciting and probably not too comfortable ride.

The 1½-ton Sputnik III was launched with an engine of between 300,000 and 500,000 pounds of thrust according to Dr. Wernher von Braun. The Soviets are reported to have two ICBM's with engines of this size. The T-3 and the T-3A are reported to have thrust ratings of 484,000 and 517,000 pounds, respectively.

Dr. Herbert F. York, chief scientist for the Department of Defense Advanced Research Projects Agency, revealed that the Department has completed its review of proposals for an engine with one million pounds of thrust. The development program will take five years and at least $200,000,000. ARPA's other interests are chiefly in the man-in-space program and the anti-ICBM problem.

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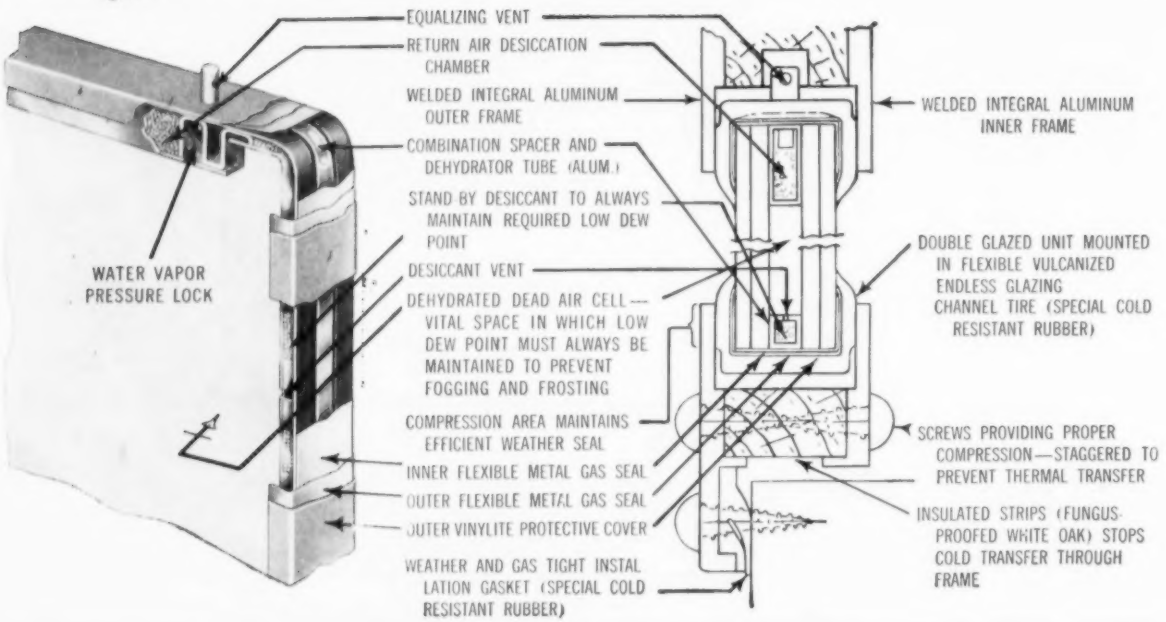
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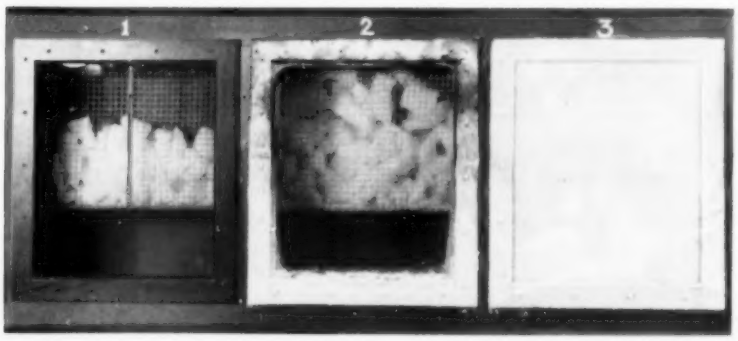

ARCTIC COLD TEST

Here is demonstrated the ability of the Edwards High Altitude Window to insulate against the transfer of heat and cold and provide clear visibility and maximum light transfer at temperatures of −65° F. and lower. Photos left to right: (Fig. 1) Edwards High-Altitude Window. (Fig. 2) Standard double-glazed, non-insulated window. (Fig. 3) Single-glazed, non-insulated window. Results of these tests demonstrate and explain why the Edwards High Altitude Double-Glazed Window is specified by the armed services in all types of mobile air-borne equipment.

Photo courtesy of Trailmobile, Inc.

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ARMAMENT ELECTRONICS

W. H. Van Vliet

Solid-State Switch.—A new solid-state switch made of a thin layer of aluminum oxide deposited in a small piece of aluminum foil has been announced by the Ordnance Corps' Diamond Ordnance Fuze Laboratories, Washington, D. C. This switch exhibits characteristics of a capacitor; however, upon application of critical voltages, the resistance drops to less than one ohm. The new solid-state switch, compared with gas tubes, is less expensive, smaller, and more resistant to vibration, radiation, and shock. No special power supply is required.

Antijam Radars.—The Air Force recently has announced that it is going to use frequency-diversity radars in an effort to reduce the susceptibility of radar to enemy jamming. These radars operate simultaneously on several frequencies at the same time. The system is one which was developed by the French.

Monopulse Radar.—The Air Force F-105 fighter will use a lightweight monopulse radar for ground mapping, avoidance of high terrain, air switch, and automatic target tracking. The system was developed by North American's Autonetics Division.

Maser.—A new type of gas Maser (microwave amplification for simulated emission radiation) has been developed under Army Signal Corps sponsorship. This new amplifier uses two cavities and a beam of ammonia gas molecules. The two isolated cavities which are connected by a gaseous beam provide input-output terminals. It is reported that the amplifier has demonstrated predictable physical phenomena and promises great freedom for controlling the gain and band width.

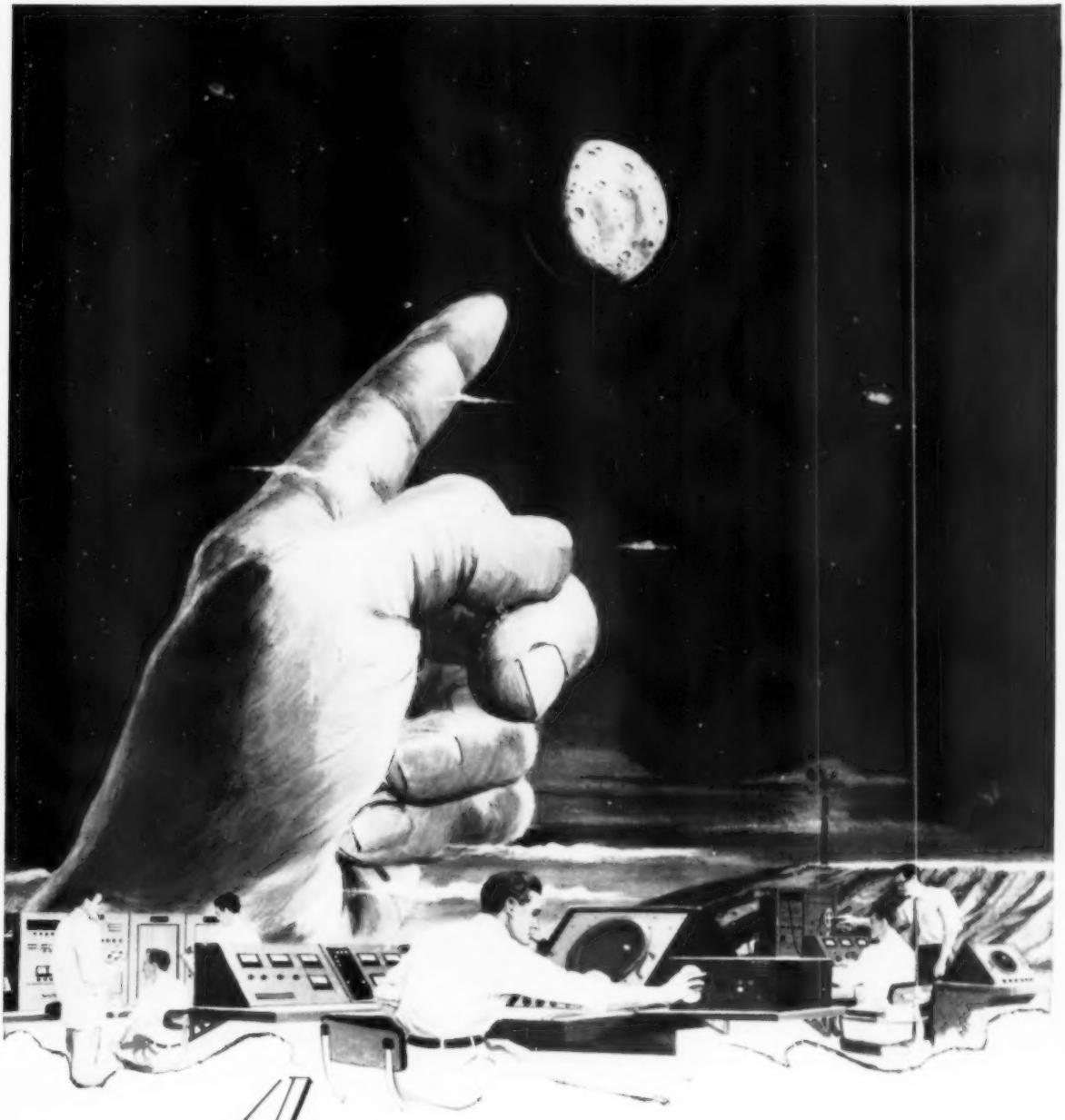
Army-Navy Instrument Program.—The Army and Navy are jointly developing a new aircraft instrument panel which, for presentation of flight information to the pilot, uses artificially simulated cues of the outside world. These cues are displayed in "human-engineered" instruments as well as being displayed on a vertical, flat, transparent cathode-ray tube which presents an anology as to what the pilot would see if he were looking through the windscreen to the outside world. These cues are effectively displayed as terrain in a pathway in the sky and appear much like a road would appear to the driver of an automobile.

Standard Modules.—Wright Air Development Center has adopted the MIL-E-19600 military specification developed by the Bureau of Aëronautics for guidance in the construction of standard modules for electronic systems to be installed in Air Force aircraft. This system of standard modules allows repackaging of a communication, identification, or navigation system according to the peculiar characteristics of a specific weapon system. The standard modules also allow a greater latitude in the modification of positions of an over-all electronic subsystem. This flexibility prevents the rapid obsolescence of electronic equipment which cannot fit into other aircraft.

B-58 Controls.—USAF's new unconventional B-58 supersonic bomber will be guided by automatic missile-type inertial controls which are as sensitive and precise as those required for the longest-range ballistic missiles. The first successful in-flight test of the B-58's radical bomb-navigation system has been completed recently. The inertial guidance "stable platforms" for the B-58 Hustler are achieving the test-flight accuracies expected. This indicates a rapid technological advance in gyroscopics for navigation systems. The controlled B-58, by means of its inertial system, can be flown for many hours, unlike the inertial guidance of long-range missiles which is effective only for a few moments. This system will do much to add to the Hustler's capabilities. (See front cover.)

Transistors.—It is reported that approximately 9,000,000 transistors were made during the first few months of 1958 in comparison with almost 160,000,000 vacuum tubes. In spite of this great difference in quantities of tubes versus transistors, the average cost of the tubes was

Lieutenant Colonel Van Vliet, U.S.A.F. (Ret.), formerly director of armament electronics, Northeast Air Command, and formerly chief of the Operations Division, Air Force Ammunition Services, is an electronics systems engineer in the California Division, Lockheed Aircraft Corporation, Burbank, Calif.



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Armament Electronics (Contd.)

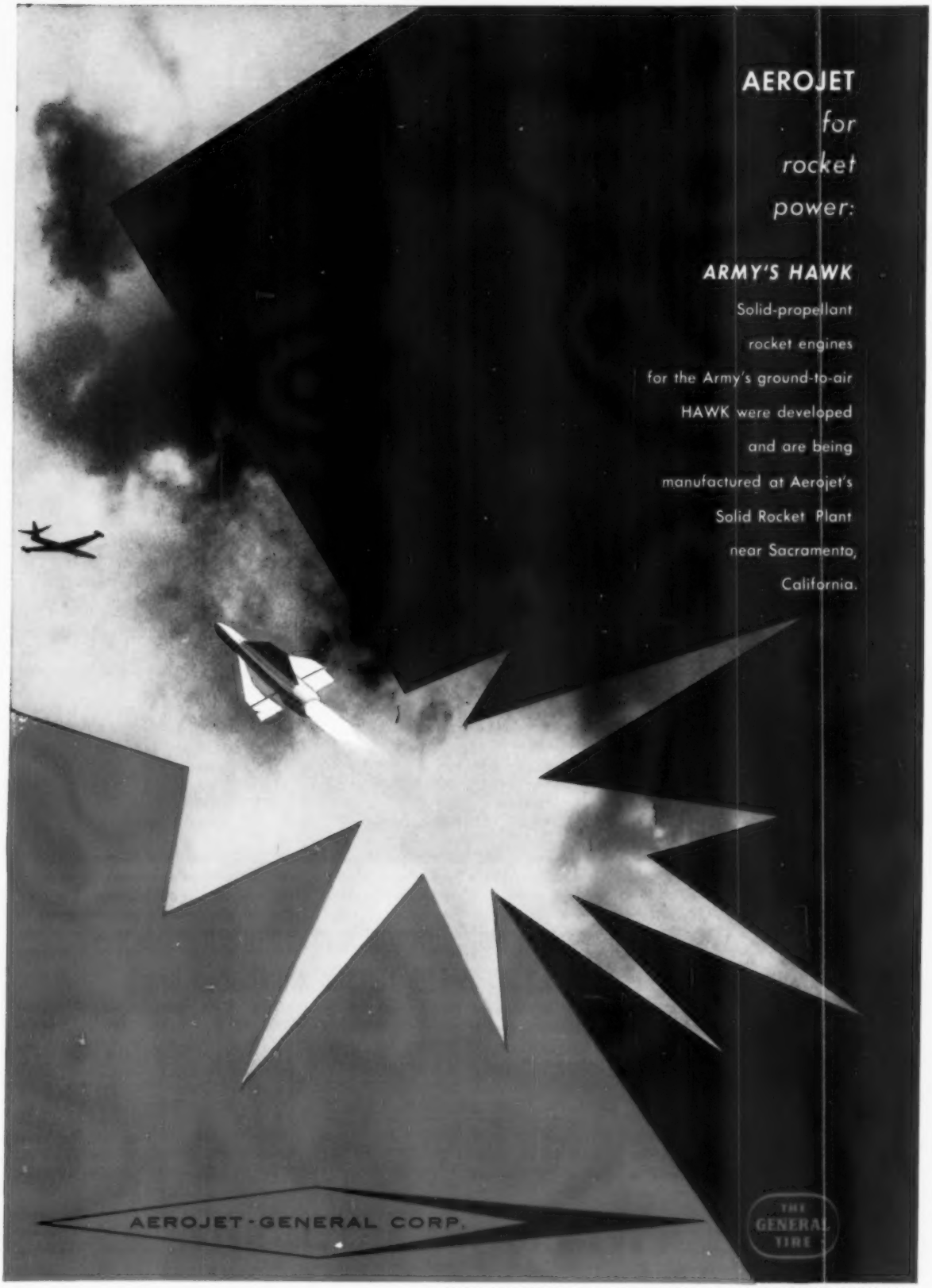
a little less than $1 while the cost of the average transistor was about $4.

Infrared.—A recent Army-Navy-Air Force project to determine infrared radiation measurements and characteristics of a number of missiles recently was completed. These tests were accomplished at the Air Force Missile Test Center, Cape Canaveral, Fla. Ship-based and land-based radiation analyzers were used. This winds up earlier tests which were conducted on aircraft radiation in Colorado. The Air Research and Development Command monitored the program.

Shared Antennae.—The Century series fighter aircraft, because of high speed and minimum availability of space for antennae, has required the sharing of an antenna by several systems. These systems operate in the same frequency band and share the antenna on a time basis. Blanking circuits are required to protect receivers from the transmission of the other systems. This antenna-sharing system reduces weight and makes for more effective operation of the communication, navigation, and identification systems utilizing the same antenna.

Sage.—The Air Force recently placed in operation the first direction center of its SAGE (semiautomatic ground environment) system at McGuire Air Force Base, N. J. This system will direct the operations of the New York Air Defense Sector. The SAGE system principally accepts and correlates target information from various types of radar systems, identifies aircraft entering the system either from flight plan or by visual means, and finally directs the employment of weapons to destroy enemy aircraft. The Air Force has announced that in three years it plans to have about thirty SAGE sectors in operation, covering the entire United States. It is further reported that Canada may install similar systems as part of the joint Royal Canadian Air Force and U. S. Air Force defense effort.

Early Missile Warning.—United States Air Force's Ballistic Missile Early Warning System will use four detection radars and three tracking radars at two sites recently selected. One installation will be at Thule Air Base, Greenland, and one in Alaska. These systems will detect missiles at ranges of approximately 3,000 miles. The system must detect a missile, determine that it is a missile rather than some other rapidly moving object, and provide data for computing launch point and impact area from the ballistics data provided by the trajectory of the missile. It is reported that the average power of these radars will be in the neighborhood of one megawatt.



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RECENT PATENTS

This department on recent military-industrial patents is being published in ORDNANCE *to keep our readers informed of the latest developments in these fields. The data are compiled by Melvin Nord, patent attorney, Detroit, Mich. Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each.*

Bomb Ejector Mechanism.—*U. S. Patent No. 2,829,561. Issued April 8, 1958, to Ernest H. Granfelt. Assigned to the Secretary of the Navy:* This invention describes means for effectively counteracting the adverse pitching moment generally developed by an externally mounted bomb or other store, such as a droppable fuel tank, when it is released from a position beneath the wing or fuselage of an aircraft.

Tracking Flares.—*U. S. Patent No. 2,829,596. Issued April 8, 1958, to Alfred C. Loedding. Assigned to the Unexcelled Chemical Corporation:* This invention provides a tracking flare for guided missiles. It is relatively small in size, and its charge may therefore be fabricated in standard pelleting machines. The pellet consists of a solid-fuel charge of the mechanical-mix variety with a composition 10 per cent by weight of aluminum, 15 per cent by weight of an asphalt resin, and 75 per cent by weight of ammonium perchlorate. To achieve the desirable red color and hence long wave length for tracking purposes, nonhygroscopic strontium nitrate is added.

The charge produces a brilliant substantially smokeless flame clearly visible from a distance of up to 15,000 feet in clear daylight, having high combustion stability during the required burning duration of 15-19 seconds. It is storable for periods as long as 5 years.

Waterproof Shot Shells.—*U. S. Patent No. 2,829,595. Issued April 8, 1958, to Aaron L. Hitchens. Assigned to the Olin Mathieson Chemical Corporation:* The conventional shot shell is formed of a paper body and a metal head. The propellent powder, primer, and shot charge are arranged in the head and body, the powder and charge being separated by wads, and the end of the body being closed by a crimping operation.

In the present invention, the brass head is eliminated. A tube of laminated aluminum foil serves as the body which also can be shaped to form a base which eliminates the necessity of a head. This results in the production of a completely waterproof shot shell.

Regulated Underwater Vehicle.—*U. S. Patent No. 2,823,635. Issued February 18, 1958, to Julius Hagemann. Assigned to the Secretary of the Navy:* It is frequently desirable to transport instruments and other exploration means above the ocean floor for various purposes such as

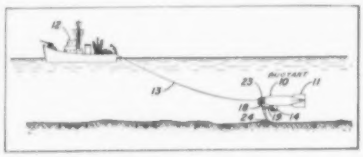


Fig. 1. Submarine vehicle

locating or detecting submerged objects. In order to obtain accurate and optimum results it is required that the instrumentation always be separated from the ocean floor by the distance for which the instruments have been designed to function. The object of the present invention is the provision of a free-floating submarine vehicle which will maintain itself at a fixed distance above the floor of a seaway through which it is moving, as shown in Figure 1.

In accordance with the invention, a submarine vehicle adapted to move (self-propelled or towed) through a seaway is provided with diving rudders biased to diving position but movable against the bias under the control of a depending tactile means which contacts the waterbed whenever the vehicle reaches the desired depth, the arrangement being such that as long as the vehicle is moving through the water its diving rudders are regulated to maintain the vehicle at all times at substantially a constant distance above the waterbed.

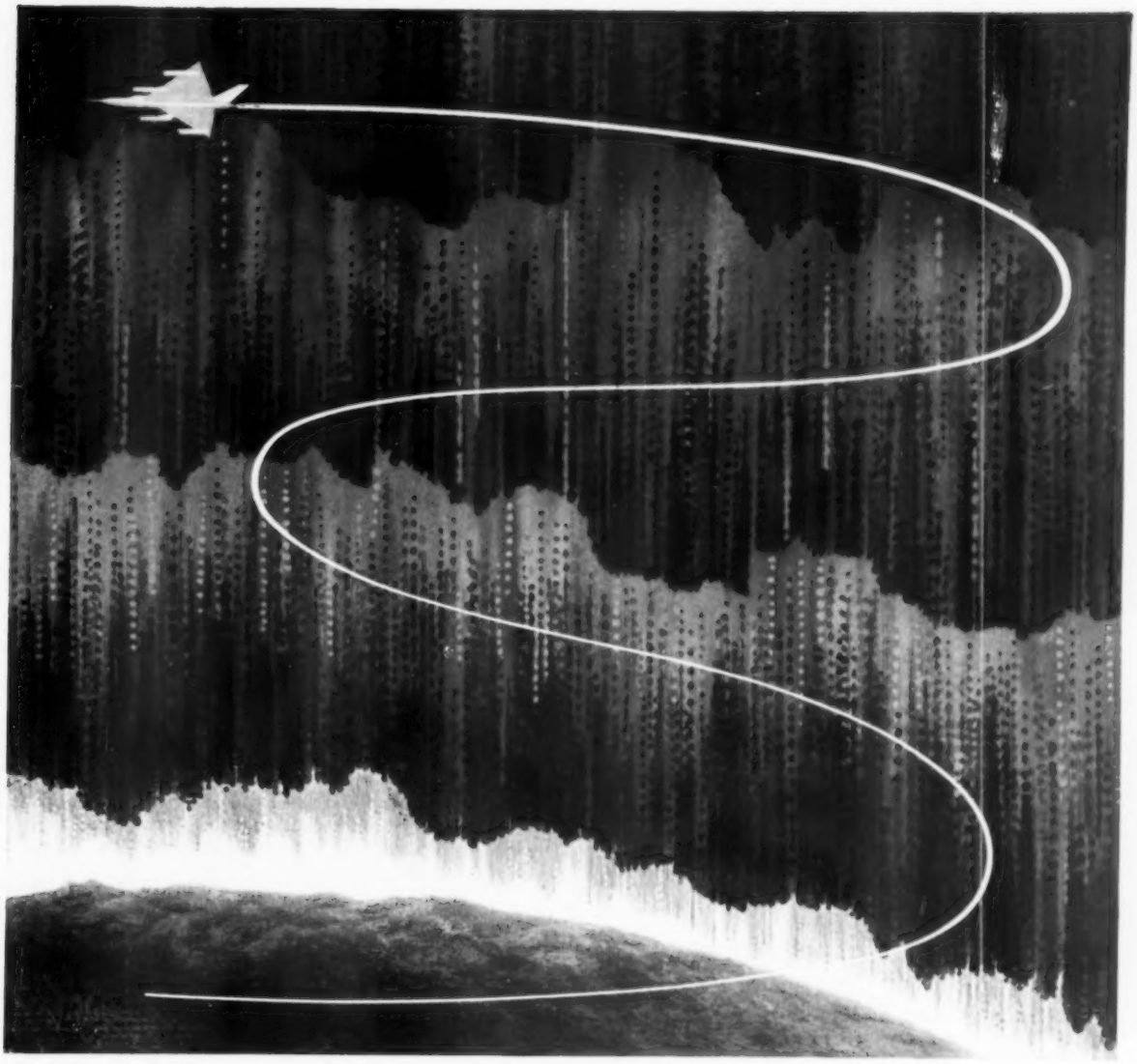
Reloading Press for Ammunition.—*U. S. Patent No. 2,829,553. Issued April 8, 1958, to John T. Twidwell:* This invention provides an apparatus for reloading ammunition in which the neck of the shell is resized and prepared for the insertion of a new bullet, the old primer removed, and a new primer inserted without necessitating the removal or repositioning of the shell being loaded.

Loading Device for Externally Mounted Tank Guns.—*U. S. Patent No. 2,830,499. Issued April 15, 1958, to Georges Even:* This invention provides a device for loading externally mounted tank guns. A loading cradle picks up a projectile from an internal magazine and brings it through an opening in the armor into alignment with the loading inlet of the weapon to be loaded. The projectile is introduced into the inlet of the gun. Means are provided for covering in advance the parts to be exposed through the opening during the loading stroke of the cradle.

Rocket Ejection System.—*U. S. Patent No. 2,833,493 and 2,833,494. Issued May 6, 1958, to John J. Pfarr and James O. Billups. Assigned to Northrop Aircraft, Inc.:* These two patents relate to means for automatically ejecting Jato-type rockets from a missile after they have expended their energy. The rockets are ejected in a manner in which they do not contact the missile to damage it or interfere with its forward progress. The pressure of the rocket's exhaust gases is utilized in the ejection operation in conjunction with another source of pressurized gas.

Land Mine Detector.—*U. S. Patent No. 2,833,143. Issued May 6, 1958, to Nathaniel B. Wales, Jr. Assigned to the Monroe Calculating Machine Company:* This invention provides apparatus for detecting the presence and location of explosive land mines. The basis of the invention lies in the fact that the great majority of land mines depend on the use of a spring-supported platform to detect the initiating target.

The apparatus described in the patent detects the presence of such a spring-supported platform by noting the phase relationship between a vibratory force applied to the earth and the displacement which results from this vibration.



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Book REVIEWS

Reviews in this issue by:

LOREN E. BOLLINGER, *registered professional engineer, Columbus, Ohio.*

COL. GEORGE S. BRADY, *consulting engineer, author, editor, Washington, D. C.*

DR. JAMES B. EDSON, *assistant to director, Research and Development, Office, Secretary of the Army, Washington, D. C.*

PETER P. GILLIS, *naval ordnance engineer, Providence, R. I.*

F. W. FOSTER GLEASON, *military historian, ordnance analyst, editor, Washington, D. C.*

DR. JOHN J. O'CONNOR, *educator, author, editor, Washington, D. C.*

LIEUT. COL. S. M. SMOLENSKY, *engineer, Andover, Mass.*

Soviet Strategy in the Nuclear Age. By Raymond L. Garthoff. New York: Frederick A. Praeger, Inc. 283 pp. $4.50.

IT requires more than a mere translation of Russian writings for an understanding of Soviet strategy, and the author of this book was well prepared for the task. He has been engaged over a long period in the intimate study of the entire field of Russian military literature, and he has the firsthand training for interpreting the intricacies of the devious Soviet mind in its semi-captive propaganda atmosphere.

The myth of Stalin as the wonderful military genius, which tended to produce stagnation, has been dissipated in Russia, and staff planning is now highly developed. Self-criticism, which seems to be scorned in the Western free nations, is used in the Soviet Union and has some valuable aspects. The Soviet organization, with a powerful Minister of Defense—a military man with the chiefs of services reporting directly to him on all strategy—is considered by them as more effective than the civilian-staff method of Western operation.

There is also an intimation throughout the book that the Soviet military mind is less tradition-bound than in the West. The present desire of the Soviets not to use nuclear weapons is not a discounting of their value but seems to be based on fear of destructive retaliation.

These are only a few of the points discussed. The book is packed with extracts from the whole range of Soviet publications, some of them security-classified in the Soviet Union. The book is unique not only because of the breadth of the research but also because of the author's interpretations of the probable significance of the statements.—GEORGE S. BRADY.

Space Flight. By Dr. Carsbie C. Adams. New York: McGraw-Hill Book Company. 373 pp. $6.50.

DR. Adams begins this stimulating exposition on space travel with a detailed historical review. Many persons connected with the early phases of astronautics are introduced and their contributions are discussed.

Next, the author covers the basic theory of rocket propulsion. The nature of orbits and the basic mechanics of satellites and space stations are given in terminology which can be understood

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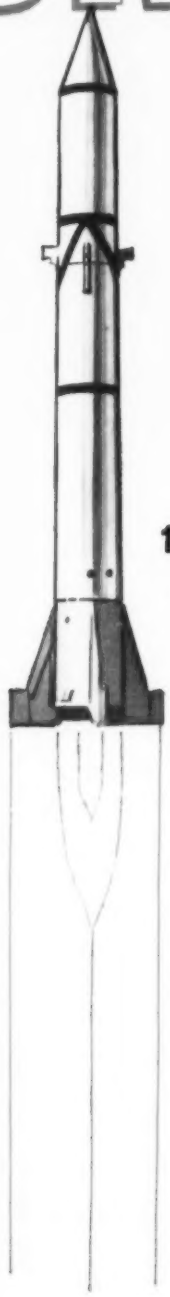

100 KW. Precise-Power Generator Sets Ordered for U.S. Missile Program

This new General Motors Diesel Engine-Generator Set is designed to meet the most exacting performance standards in supplying power for radar, ground support and other facilities for various missile programs of the U. S. Army, Navy, Air Force and Marine Corps.

Developed in conjunction with the Corps of Engineers, U. S. Army, this Precise-Power unit combines the time-proved GM "6-71" 2-cycle Diesel engine with a 100 KW. Delco generator, equipped with a specially designed regulating system for utmost accuracy. Weight is kept to a minimum (only 5,800 pounds) through extensive use of aluminum in both engine and generator components.

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Book Reviews (Contd.)

by technically trained people who are not in this field themselves.

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The latter third of "Space Flight" is written on problems that man will encounter once he arrives in space. Chapters on communications, navigation, the moon, and interstellar flight complete the volume.

This well-referenced work is not just another book on space flight—it will become a classic to future spacemen and their earth-bound followers.—LOREN E. BOLLINGER.

Aircraft and Missile Propulsion, Vol. I. By M. J. Zucrow. New York: John Wiley & Sons, Inc. 538 pp. $11.50.

SINCE Dr. Zucrow's publication of "The Principles of Jet Propulsion and Gas Turbines" there has been an extremely rapid increase in the development of engines for high-speed aircraft and missiles with a commensurate increase in the volume of literature devoted to this subject.

This is the first of a 3-volume work which discusses the underlying principles of the technology pertinent to propulsion engines; *e.g.*, the turboprop, the turbojet, the ramjet, the liquid-propellant rocket, and the solid-propellant rocket. Volume II will deal with the analysis of the cycles of the above engines, while Volume III will be concerned with the components for these engines.

The material is clearly presented with notation and nomenclature being carefully handled to permit use of the volume with minimum assistance from an instructor. There are a large number of illustrative problems plus many exercise problems with answers. Abundant and up-to-date references are presented at the end of each chapter for further study.

This volume achieves its objective of furnishing the student and practicing engineer an up-dated understanding of the fundamental principles governing the operation of high-speed engines.—S. M. SMOLENSKY.

What's Going on in Space? By Comdr. David C. Holmes. New York: Funk & Wagnalls Company. 256 pp. $3.95.

THIS one won't strain your brain. Yet it will make you think. The author in his prologue states: "I speak for all of us who think and feel and whom time consumes. I am like a man journeying through a forest, aware of occasional glints of light overhead, with recollections of the long trail that I have traveled, and conscious of wider spaces ahead. I want to see where I am going and why I am traveling at all." And he believes "we carry the torch for more than we know—perhaps for more than we can ever know."

The body of the book, in a sprightly and somewhat lyrical prose style, develops the past and future story of astronautics. The account is ornamented with philosophical observations and an assortment of interesting anecdotes about astronautic events and personalities. Technical details are sometimes enmeshed in a glittering veil that the experts may view as poetic license and other readers won't notice at all.

A few chapter headings: "A Voice from the Cosmos," "Prelude to Adventure," "Design for the Unknown," "Shooting the Moon." The chapter on "The Ultimate Conquest" contains a good statement of a fighting man's philosophy in the astronuclear age.

Commander Holmes has a firsthand knowledge of many recent astronautic events. His book has an introduction by Rear Adm. Rawson Bennett, Chief of Naval Research.—JAMES B. EDSON.

The Gun Digest. Thirteenth Annual Edition, 1959. Edited by John T. Amber. Chicago: Gun Digest Company. 320 pp. $2.95.

IT is no mean feat to edit a gun book for thirteen years and avoid monotony, but John Amber has done just this. Of course its base is modern (nonmilitary) small arms, but there is always added a judicious selection of collecting, hunting, police firearms, and history to fill any man's interest. Even the gun tricks and trick guns of movie gunmen are revealed.

Some 500 photos and drawings illustrate more than 40 articles and departments. It would be difficult to claim that "guns" were not completely "covered," but next year, we will wager, will be another story!—F. W. FOSTER GLEASON.

The Splendid Little War. By Frank Freidel. Boston: Little, Brown & Company. 314 pp. $8.50.

THE title of this unusual book is derived from a sentence in a letter which John Hay, the United States Ambassador to England, wrote to Col. Theodore Roosevelt of the Rough Riders. Mr. Hay stated that the war was begun with the highest motives, was carried on with magnificent intelligence and spirit, and was "favored by that fortune which loves the brave."

Professor Freidel underscores the fact that the war may have been splendid for diplomats abroad and for citizens at home who took great pride in what was reported to be a series of spectacular tri-

umphs. But for the heroic men who fought the 4-month conflict, especially those decimated before Santiago, it was as grim, dirty, and bloody as any war in history. The Spanish-American War may have been a minor struggle, but only the incredible ineptitude of the Spaniards and the phenomenal luck of the Americans kept it from becoming a national disaster.

Today the war seems something far less than a crusade—and scarcely splendid. Professor Freidel presents the true character of the war, as recounted by eyewitnesses, and includes some 300 excellent photographs and samples of the work of such competent artists in the field as Howard Chandler Christy and John T. McCutcheon.—JOHN J. O'CONNOR.

The Hunters and the Hunted. By Adm. Aldo Cocchia. Annapolis: U. S. Naval Institute. 180 pp. $3.50.

THIS is the story of Italy's few naval victories during World War II, supplemented by accounts of other engagements claimed as "moral" victories by Admiral Cocchia. It calls to mind the United States Navy's emphasis on personal heroism and bravery following the 1923 disaster in which seven destroyers were accidentally grounded.

Nevertheless, this narrative has much in its favor. The admiral's warm informality and frankness have been wonderfully preserved by the translator, M. Gwyer. One can almost see the excited gestures, the dignified pose, the impassioned looks. Moreover, it is the story of patriots—men proud of their flag. Through these men the history of the war is presented, as Plutarch presented much of ancient history.

Although lives are not compared, as in Plutarch, the Italian seamen often are compared with the British, and the principal difference is always that the British had radar. Perhaps this is thought an unfair advantage. At any rate the British Isles are omitted from the world chart on page 120!—PETER P. GILLIS.

This Glorious Cause—The Adventures of Two Company Officers in Washington's Army. By Herbert T. Wade and Robert A. Lively. Princeton: Princeton University Press. 254 pp. $5.

PRIOR to his death in 1955, the senior author of this volume, Mr. Wade, had completed the basic research—some 2,500 typed pages describing the fortunes of his ancestors. Mr. Lively is responsible for the selection, interpretation, and writing of the book.

The two company officers, whose adventures provide an extended footnote to general accounts of the American Revolution, were a carpenter, Nathaniel Wade, and a cobbler, Joseph Hodgkins, both of Ipswich, Mass. The two men fought at Bunker Hill and on Long Island, attacked at Trenton and Princeton, and helped to secure victory at Saratoga.

The correspondence on which the book is based is rich in details of battle and life in the camps. Hodgkins mailed his laundry and mending home to his wife. Wade had the usual difficulties in trying to persuade his men not to go on picket guard without shoes. Neither officer was able to discourage the citizen-soldiers from making a game of catching cannon balls before they stopped bouncing.

This story of the two officers in the middle ranks who fought for "this glorious cause" will help our generation to understand more clearly and more reverently the true nature of self-sacrificing patriotism.—JOHN J. O'CONNOR.

Sherman—Soldier, Realist, American. By B. H. Liddell Hart. New York: Frederick A. Praeger, Inc. 456 pp. $7.50.

IN preparation for the Civil War Centennial, a flood of both new and reprint books may well be upon us. This is one of the best of the latter. First issued in 1929, the book was esteemed as a scholarly analysis of the mind and character of this military leader.

This is done in a thorough and most competent manner. Not a few will be surprised to learn of Sherman's views on the vital question of slavery. While opposing its extension, "in prudence and moderation," as late as 1855 he was convinced of its necessity in the Gulf States.

Liddell Hart's military evaluation is usually sound, even brilliant. Yet, occasionally, one is conscious of the perennial weakness of the Englishman's 4,000-mile-distant viewpoint of strictly American military history.

Yet this is a volume of much worth to the serious student of the American Civil War, affording an opinion rather remote from those "prejudices" which, however unconsciously, affect every American.—F. W. FOSTER GLEASON.

The Schlieffen Plan—Critique of a Myth. By Gerhard Ritter. New York: Frederick A. Praeger, Inc. 195 pp. $5.50.

HERE for the first time the student of military history may examine the full text of Schlieffen's military testament and the relevant parts of other memoranda which shed light on the evolution of the plan. One of Germany's most distinguished historians offers for consideration an analysis of the historical features of Schlieffen's plan compared with those of his predecessor and his successor.

Dr. Ritter believes that the significance of the Schlieffen Plan extends far beyond purely military history. Politically, for example, it was disastrous for Germany. The plan has become the center of every discussion about the role of the German General Staff before 1914 and about the whole question of German "militarism."

Was Germany's defeat in World War I the direct result of the second Moltke's departure from the plan? In an illuminating foreword, B. H. Liddell Hart expresses the view that the basis of the Schlieffen formula for quick victory amounted to little more than a gambler's belief in the virtuosity of sheer audacity. Its magic is a myth. As a strategic concept it proved a "snare and delusion" for the executants, with fatal consequences that were inherently probable from the outset.—JOHN J. O'CONNOR.

BOOKS RECEIVED

Aircraft Communications Systems. By J. H. H. Grover. New York: Philosophical Library. 127 pp. $6.

Baa Baa Black Sheep. By "Pappy" Boyington. New York: G. P. Putnam's Sons. 384 pp. $4.50.

Basics of Digital Computers. Vols. I, II, III. By John S. Murphy. New York: John F. Rider Publisher, Inc. 416 pp. $2.50 per vol.; $6.95 set.

Bill of Rights, The. By Learned Hand. Cambridge: Harvard University Press. 100 pp. $2.50.

Danger in the Air. By Oliver Stewart. New York: Philosophical Library. 194 pp. $6.

Electrostatics. By Dr. Alexander Schure. New York: John F. Rider Publisher, Inc. 72 pp. $1.35.

Exhibition Drills. By William M. Glasgow, Jr. Harrisburg: Military Service Publishing Company. 198 pp. $2.50.

Impedance Matching. By A. Schure. New York: John F. Rider Publisher, Inc. 128 pp. $2.90.

Manpower for Government—A Decade's Forecast. By Eli Ginzberg and James K. Anderson. Chicago: Public Personnel Association. 34 pp. $2.

Missile Engineering Handbook. By C. W. Besserer. New York: D. Van Nostrand Company. 600 pp. $14.50.

Personnel Research Frontiers. By Cecil E. Goode. Chicago: Public Personnel Association. 176 pp. $3.50.

Proceedings of the Fourth Annual Computer Application Symposium, 1957. Armour Research Foundation of the Illinois Institute of Technology. 126 pp. NP.

Transistor Technology. Vol. III. Edited by F. J. Biondi. New York: D. Van Nostrand Company. 416 pp. $12.50.

Weldor's Training Manual: Inert Gas Process. Chicago: Kaiser Aluminum & Chemical Sales, Inc. 144 pp. $1.

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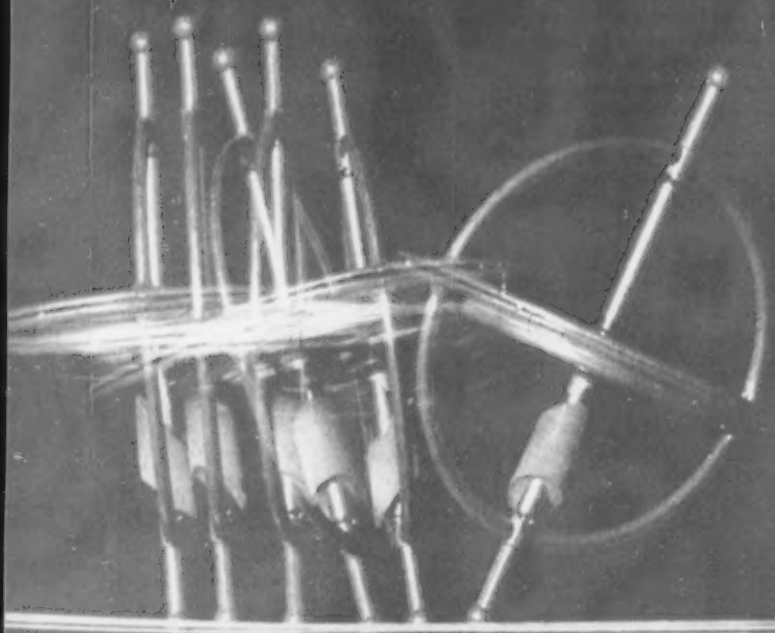

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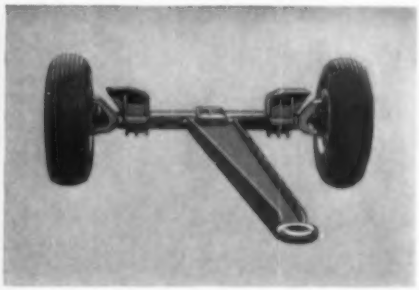

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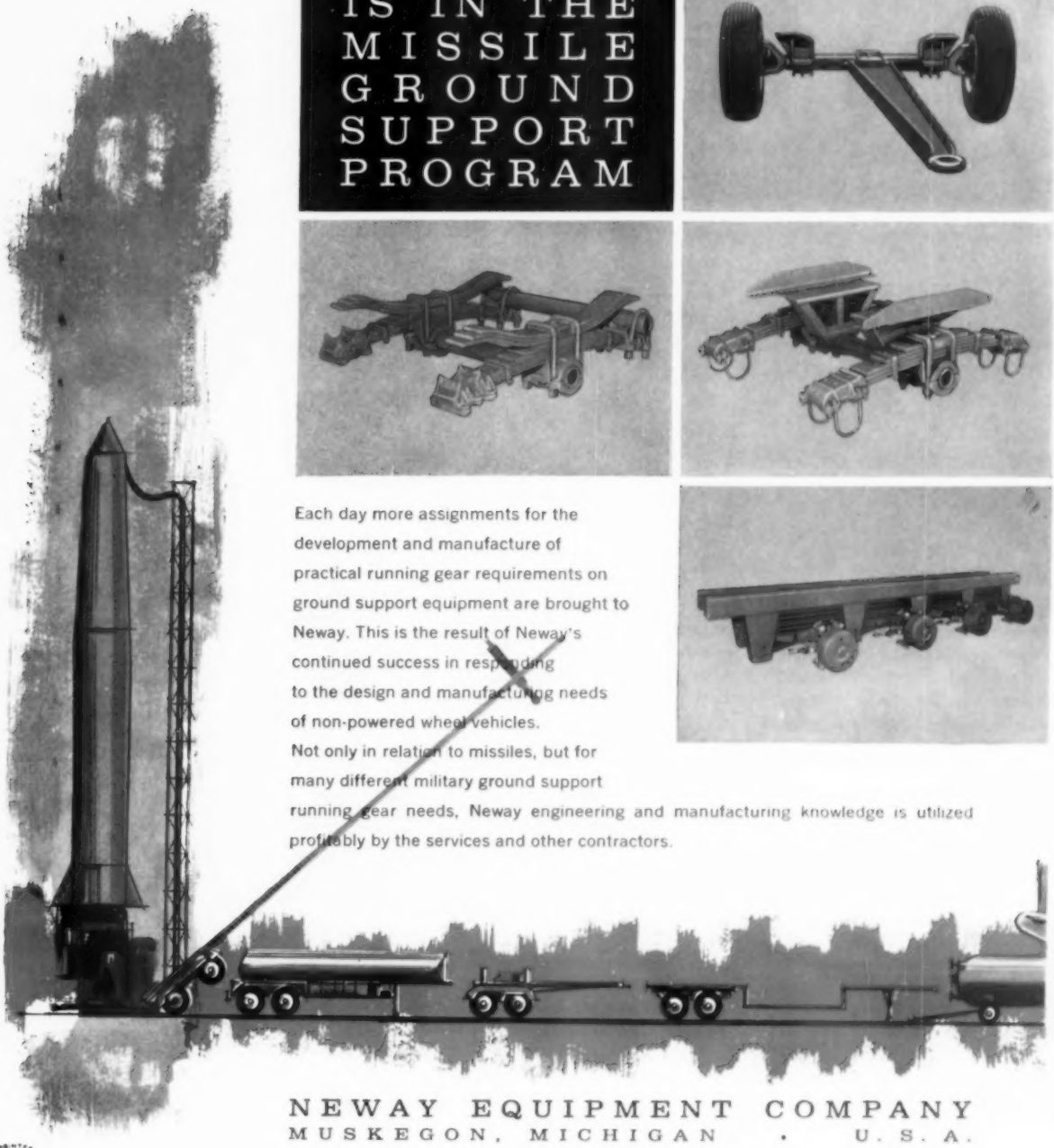

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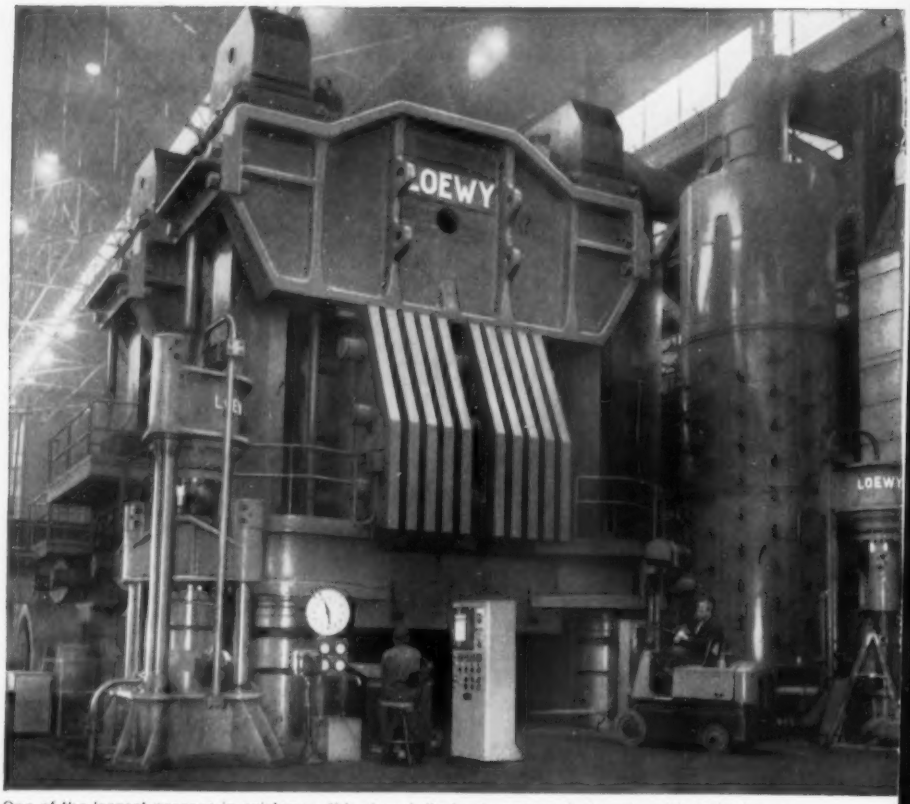

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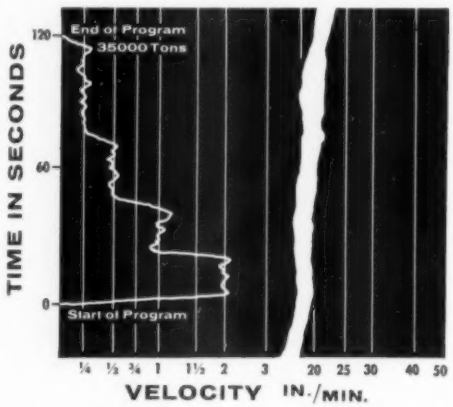

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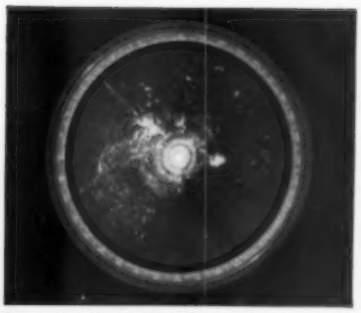
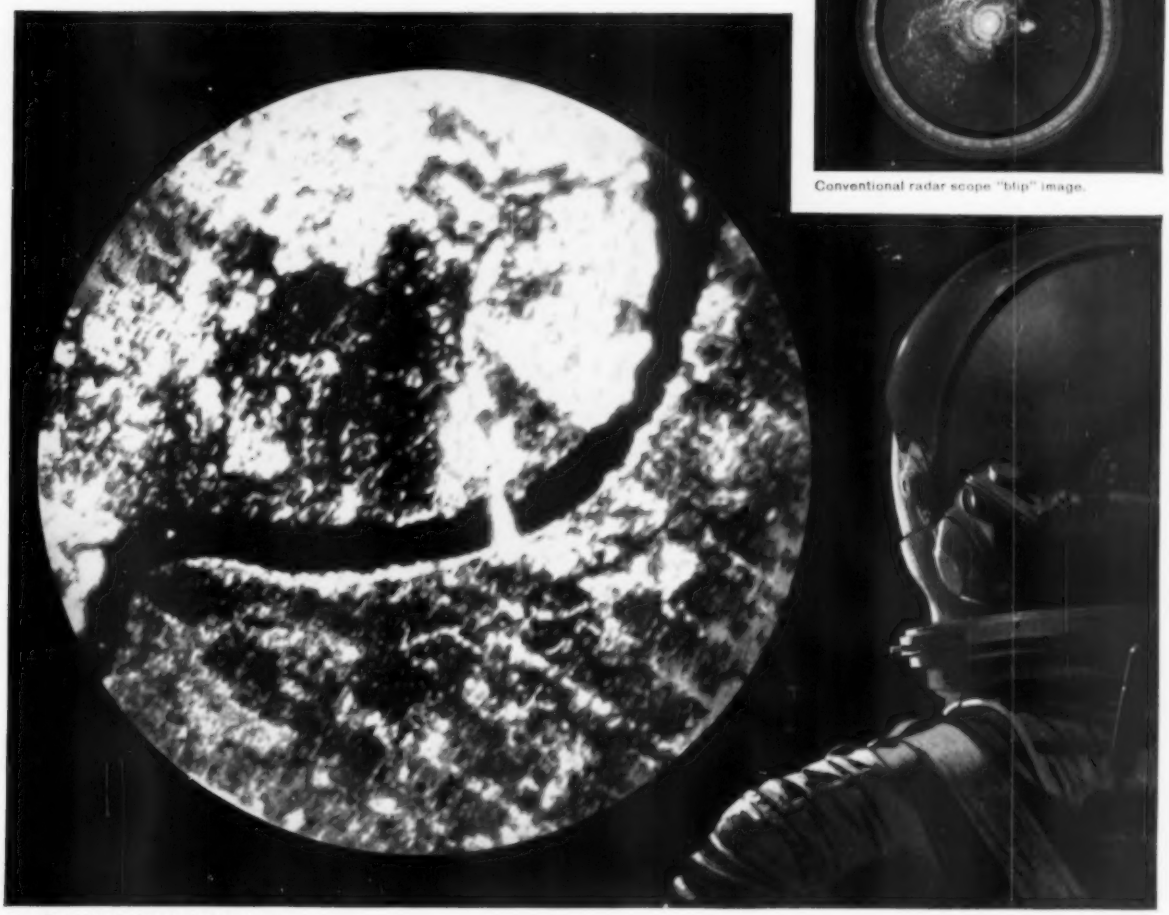


Conventional radar scope "blip" image.



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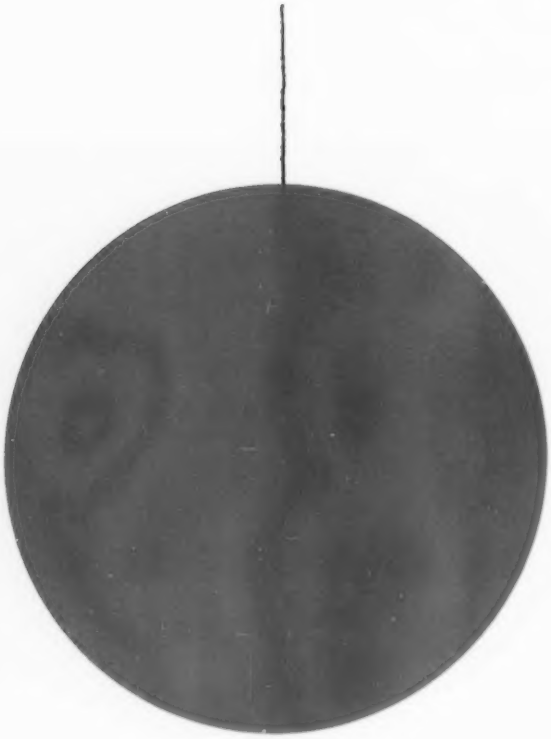

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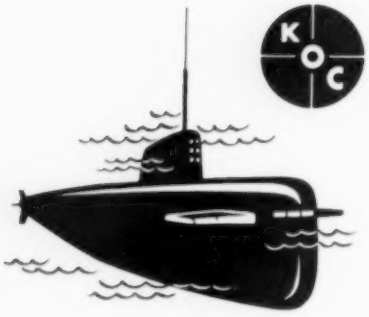

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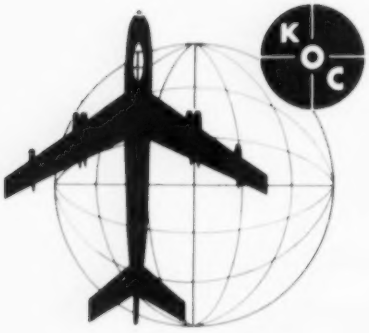

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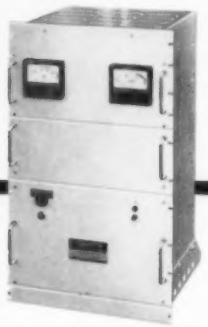

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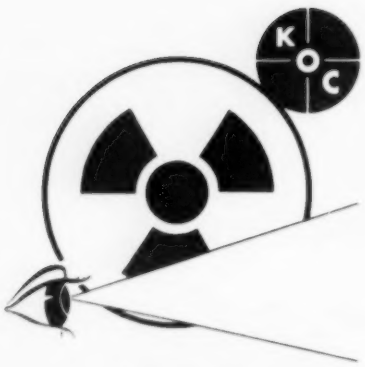

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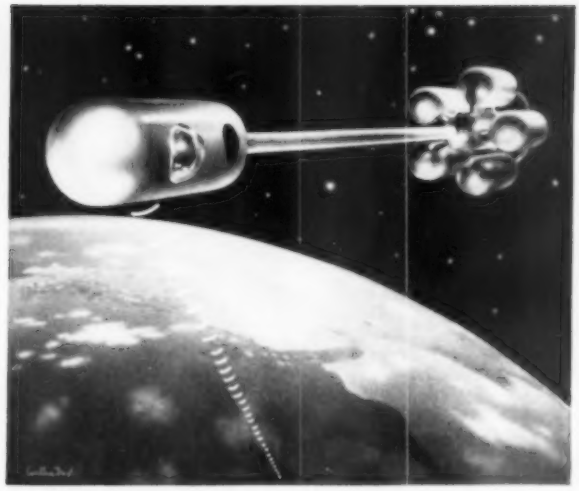

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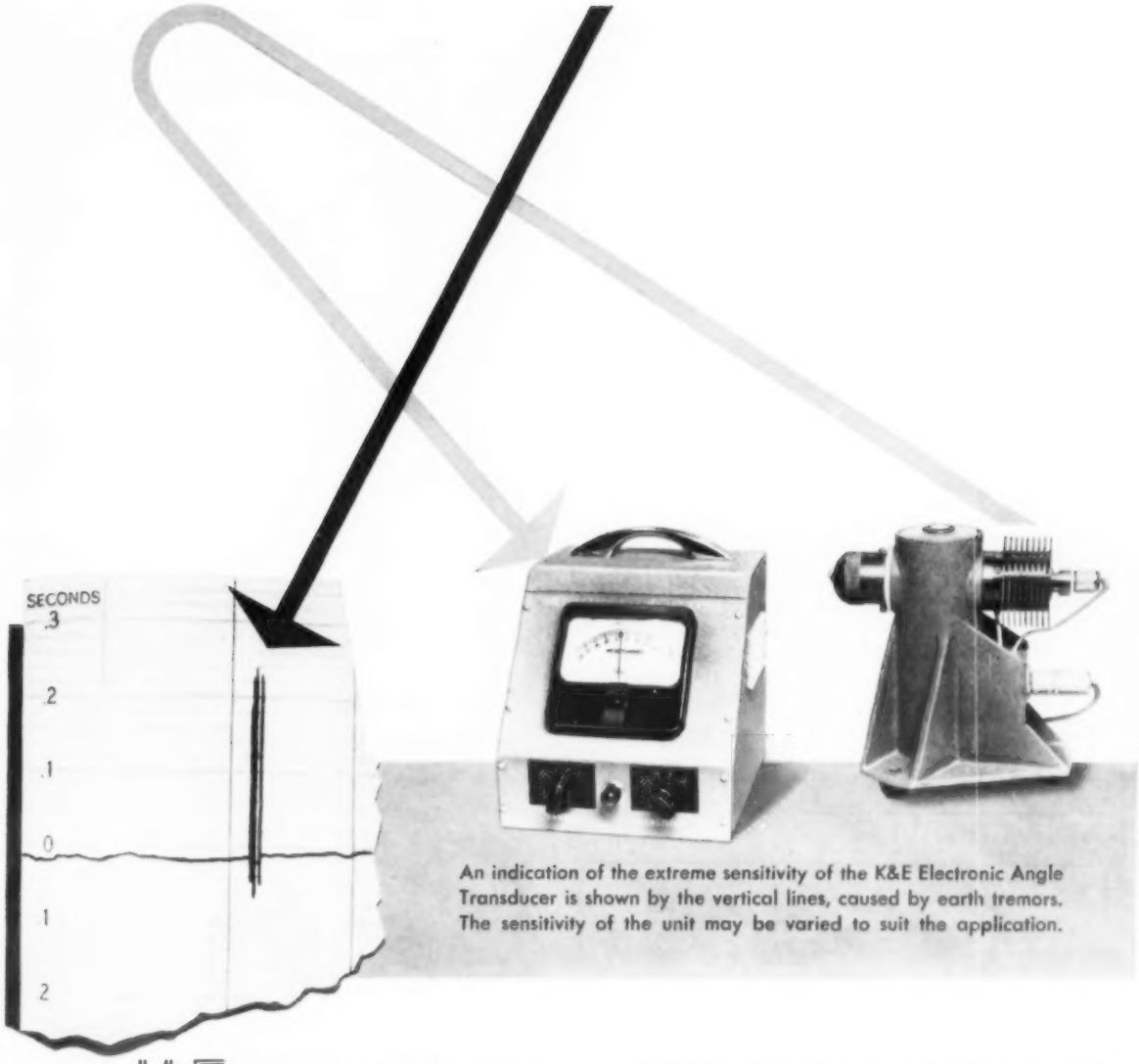

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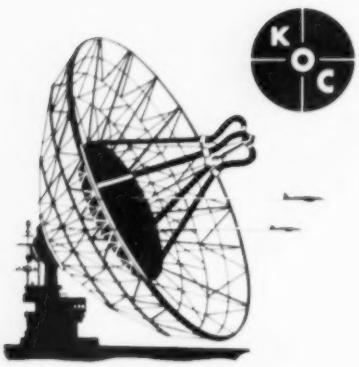

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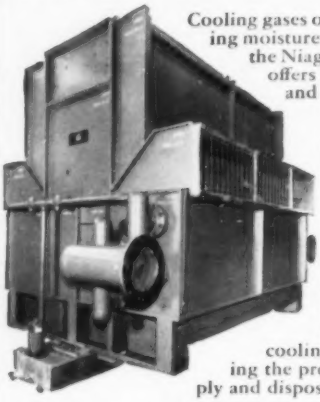

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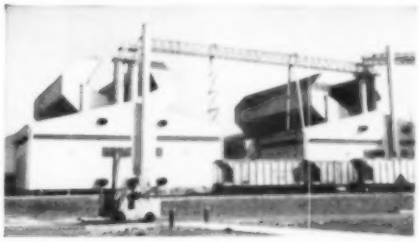

Close-up view of glass furnace buildings which appear at upper left in the larger photo. Note the unusual design of the rooftop ventilating systems.

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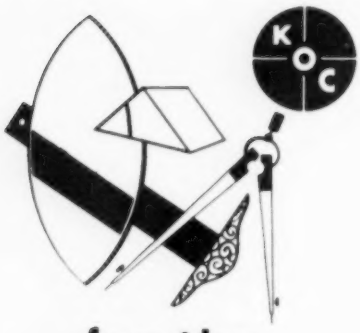

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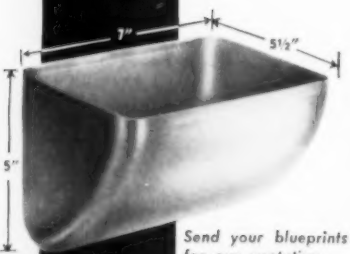

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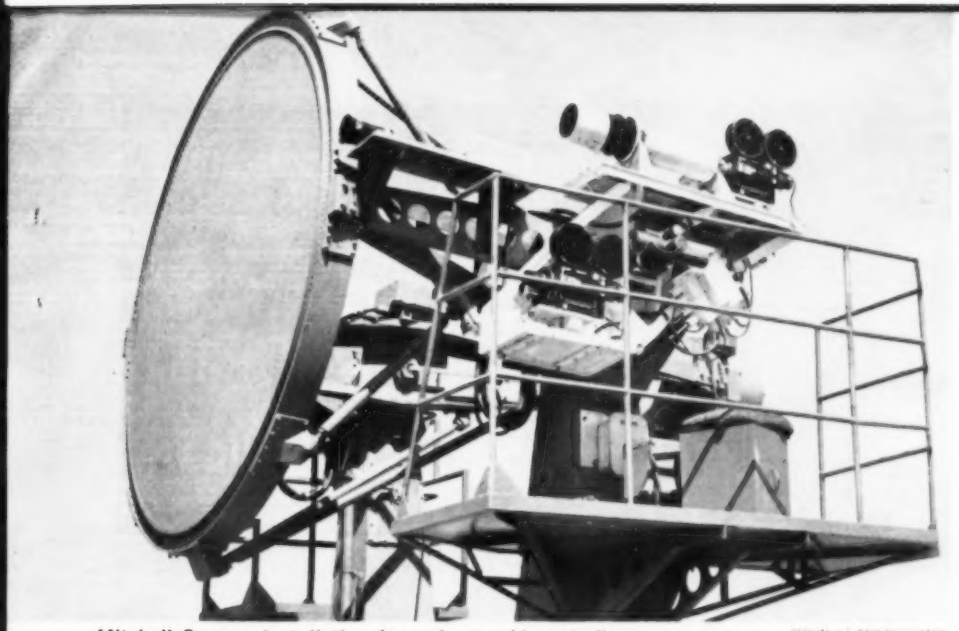

Mitchell Camera installation for radar tracking studies.

HOW MITCHELL CAMERAS SUPPLY VARIED DATA IN ROCKETS AND MISSILES DEVELOPMENT

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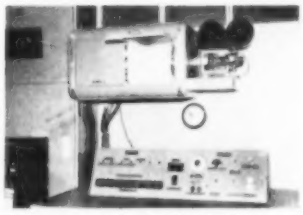

Data dial instrumentation by Mitchell camera.

Extensive testing instruments incorporating Mitchell 16mm, 35mm and 70mm cameras provide key data at the U.S. Naval Ordnance Test Station at China Lake, Calif., one of the primary weapon development centers of the Navy's Bureau of Ordnance.

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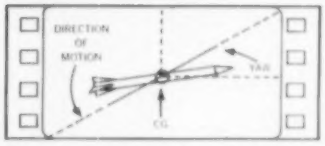
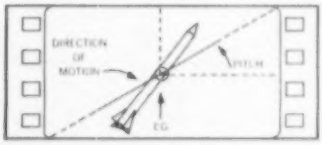


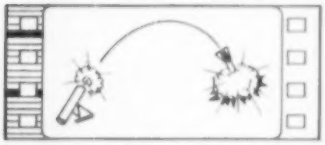
Yaw—Side-to-side motion of missile.



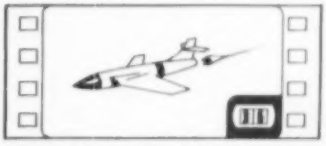
Pitch—Up-and-down motion of missile.

Roll—Turning motion of missile.

Miss Distance—Gap between missile and target at point of interception.

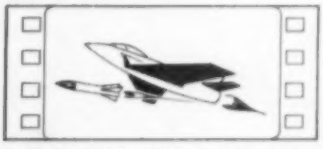


Flight Time—A series of lines on film; timed to accuracy of 1 millisecond.



Position Data—Target location with azimuth and elevation readings.

Pictorial Record—Record of all visible actions during test.



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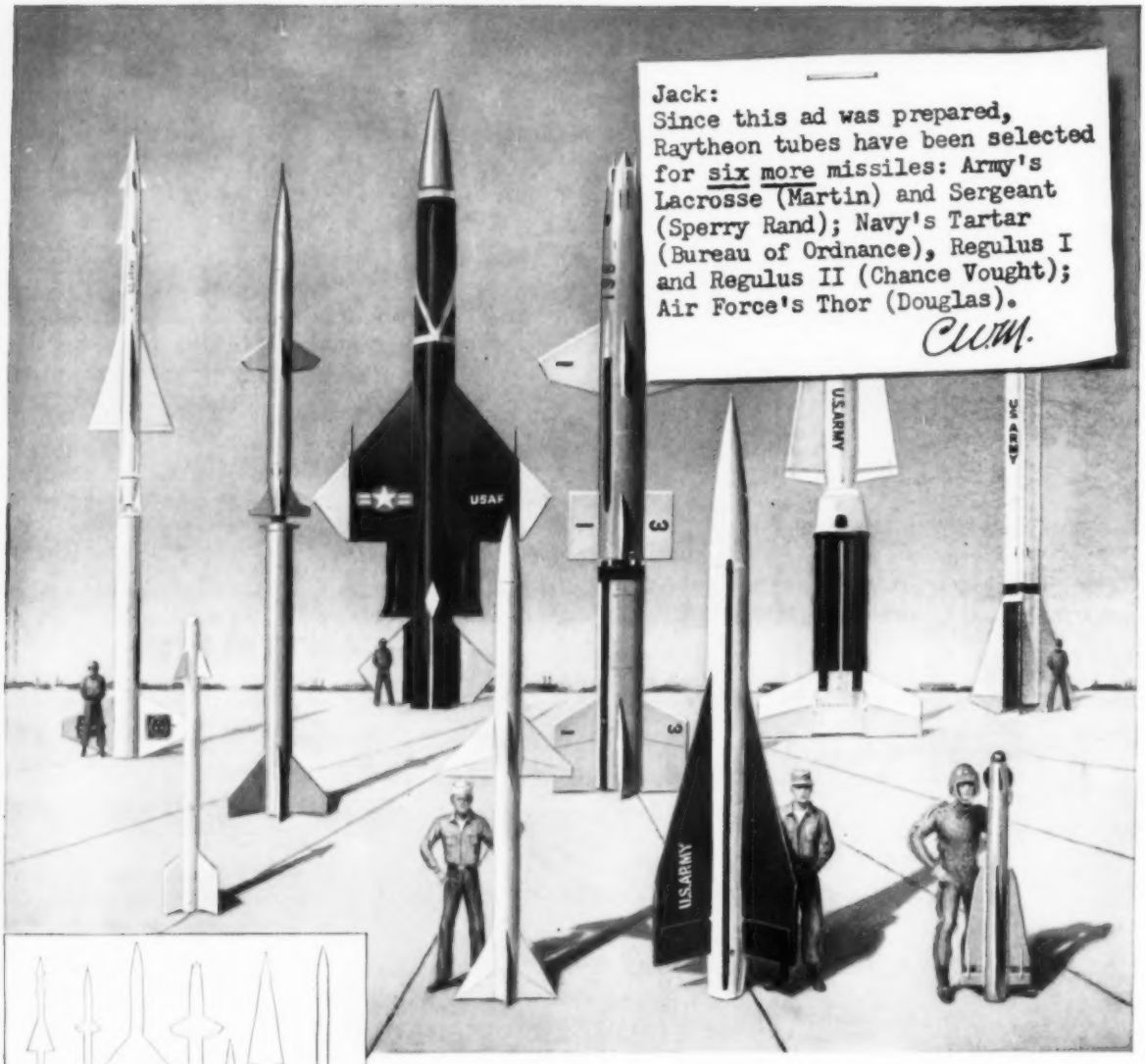
Jack:
Since this ad was prepared, Raytheon tubes have been selected for six more missiles: Army's Lacrosse (Martin) and Sergeant (Sperry Rand); Navy's Tartar (Bureau of Ordnance), Regulus I and Regulus II (Chance Vought); Air Force's Thor (Douglas).
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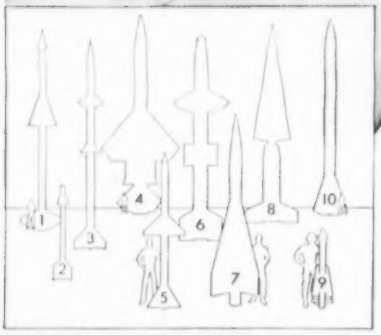

1. **Nike Ajax.** Army. Ground-to-air. Prime contractor: Western Electric.
2. **Sidewinder.** Navy. Air-to-air. Prime contractors: Philco; General Electric.
3. **Terrier.** Navy. Surface-to-air. Prime contractor: Convair.
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6. **Talos.** Navy. Surface-to-air. Prime contractor: Bendix.
7. **Hawk.** Army and Marine Corps. Ground-to-air. Prime contractor: Raytheon.
8. **Nike Hercules.** Army. Ground-to-air. Prime contractor: Western Electric.
9. **Falcon.** Air Force. Air-to-air. Prime contractor: Hughes Aircraft.
10. **Corporal.** Army. Ground-to-ground. Prime contractors: Firestone; Gilfillan.

10 MAJOR U. S. MISSILES RELY ON RAYTHEON TUBES

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Armament Technology

This section of ORDNANCE contains selected papers on armament technology presented at meetings of Technical Divisions and Committees of the American Ordnance Association and contemporary articles on armament research, development, manufacture, and field use

Missile Shelters

Protection can vary depending on type of missile to be shielded

A. Mirel

General Engineering Laboratories, American Machine & Foundry Company, Greenwich, Conn.

MISSILE shelter design is a new phase of architecture. In the early history of American missile development, the ground environment, including the shelter, received very little attention. It was natural to place the emphasis on the development of the bird itself and let the other elements take care of themselves.

Nowadays we recognize that this sort of approach does not work—that the missile system must be developed as a whole with all the elements being developed more or less concurrently.

The most important item to note, and the thing that serves as a sound starting place for any discussion of the shelter, is that it is an integral part of the missile system and must be considered primarily in the light of its compatibility with the system.

WE are all familiar with the great multiplicity of modern missiles. Even if we eliminate from the discussion all but the ground-to-ground and ground-to-air types, the number of sizes, configurations, and missions is impressive. It should be remembered that each type has its own shelter requirements.

In the matter of size and complexity the shelter may run the gamut from a simple cover over certain vital components of the missile to a huge underground network designed to protect the missile and supporting personnel from nuclear attack.

Among the welter of requirements that a shelter must satisfy, four stand out as being of primary importance in defining the nature of the structure. These are: (1) size of missile to be sheltered, (2) whether or not the missile is to be protected against nuclear attack, (3) whether or not it is to have reload or multiple-housing capabilities, and (4) the angle of launching. Once these elements have been established as parameters, the designer's area of activity is considerably restricted.

Some requirements relate to the shelter itself. These may include ease of erection, economical use of materials, ease of transport, availability of materials, and prefabrication capabilities.

OTHER requirements are intimately concerned with the actual operational use of the missile such as integration of shelter with launcher complex, means of egress of bird at time of launch, methods of fueling, entrance of servicing vehicles, provision for accidental warhead detonation, provision for storage of other components of the system besides the missile, and provision for escape of exhaust gases.

There are two important considerations in the design of a missile shelter that are worthy of special emphasis. One is the matter of designing the shelter for a given service life. In domestic architecture we are accustomed to the

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Constant training is required
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Dr. David Hart
Improvements are still necessary

idea that a structure is built to last for a period of fifty years. With a missile shelter we are concerned with a structure that is built to last for a probable period of about five to ten years. Thus it is not economically feasible to use the same kind of construction techniques we are familiar with in conventional structures.

An ideal design for a given missile requirement may at first glance appear to be marginal. It is only when we consider that the life expectancy of the structure varies greatly that the true merits of the design become evident.

THE other aspect concerns the notion that a missile shelter may be a "one-shot" item and that structural problems can be treated quite casually as a result. The point to be borne in mind is that although a shelter may be used only once, its related components must function perfectly on that occasion or the whole system is worthless.

Missile designers are very much aware of the importance of reliability as it affects the bird.

The shelter designer bears in mind all the requirements of the system and arrives at a configuration on the basis of its ability to satisfy them. Economics, of course, exercises a final discipline over the design, for obviously the cost of the shelter must represent a sensible fraction of the cost of the entire system.

The engineering approach to shelter problems involves the systematic analysis and evaluation of these and other elements. One method of arriving at a solution is to generate a number of concepts that satisfy the specification as set forth, then as a team, evaluate each in a detailed, systematic fashion to arrive at a final recommendation.

There are many shapes, types, and construction techniques open to the missile shelter designer. Bearing in mind the inherent weakness of any effort to draw general conclusions, here in brief, are some of the important approaches in use today.

Broadly, shelters are either of the "hard" or "soft" type. The soft type gives protection against the elements—sun, wind, rain, and ice. "Hard" protection, on the other hand, involves protection against nuclear attack and as such involves a myriad of problems unheard of in ordinary shelter design.

Most shelters designed today are of the soft construction type. Among the various ways of approaching this problem, four are of particular importance and deserve specific description. These are classified as: the blanket; the inflatable structure; the framed, nonstructural skin type; and the structural skin type.

The blanket type uses the missile itself as the supporting structure. A cloth or plastic cover is held in place by ropes. A blanket is not, of course, a structure in the normal sense of the word, but since it does offer protection, it is reasonable to discuss its uses in an article of this kind.

A blanket can be draped over the missile in horizontal position and easily removed prior to erection for firing. If the missile is to be stored vertically, the blanket can be contour-fitted, and provision can be made for easily ripping it away prior to firing, or a system of break-through release can be used.

An important feature is that the cost of the blanket type of protection is low. Packaging and transportation are easy. Attachment to the bird should normally be easy, but under windy conditions some difficulty may be experienced.

In short, the blanket offers many practical advantages, and if it offers all the protection that is needed, it should be used. However, this type of protection leaves a wide range of requirements unsatisfied. Specifically, the blanket covers only the bird and could not be used when it was desired to shelter personnel as well. It does not lend itself to multiple sheltering of missiles and does not offer adequate protection against flying or wind-blown objects.

A particularly promising new development is the air-inflated structure. (Fig. 1.) Such structures came into existence as a result of a military demand for a thin, lightweight all-weather protection cover for radar antennas in the Arctic. The air-supported radome is a coated fabric envelope supported and held rigid by maintaining a small differential pressure within the unit. The required pressure is supplied by a low-horsepower blower. There are no supporting columns or roof trusses of any kind to obstruct the interior space. These structures, which have been in service for more than six years, have been able to weather the most severe storms.

The cost of the air-inflated structure is approximately 1/3 that of a conventional lightweight structure. The material used, either plastic or fabric, is inexpensive and in plentiful supply. Such materials cost from $3 to $5 per square yard. Lightness aids transportability and makes for safe erection by unskilled personnel.

Stability of base and air tightness are both achieved by anchoring the fabric along its base periphery either by weights or fasteners. This eliminates the need for conventional footings which are far more expensive. Erection time is a matter of hours using unskilled personnel. Scaffolds, cranes, and derricks are not necessary, and removal to a new location is easily accomplished.

IN use, the inflated structure has a number of important advantages. The whole surface of the structure can be pulsated by the blower thereby getting rid of accumulated ice. The action is similar to that of the rubber aircraft wing deicer. This feature would be particularly important in the sections of the world where heavy icing is encountered.

One of the most important aspects of any shelter design is the means by which egress of the missile is accomplished. In a conventional structure, carefully designed doors are employed. In the inflatable structure a break-through top performs this function.

The manner in which the break-through is accomplished can be predetermined by carefully weakening certain lines. It also may be possible to accomplish the disposal of the shelter egress section by means of chemical reaction. In either case, the means of egress can be made thoroughly reliable.

In use it may be particularly important that the structure be shock-resistant. The inflatable shelter has inherently greater shock resistance than any comparable conventional structure. The weave and nature of stress distribution tend to prevent tearing if the surface is punctured.

This article was taken from an address given by Mr. Mirel before a recent meeting of the A.O.A. Missiles and Astronautics Division held at Redstone Arsenal, Ala.

The heating of these structures in cold weather must be considered. Heat transfer through an inflatable structure is estimated at 0.8 Btu/hr./deg. F. per square foot. This value was calculated for a temperature differential of approximately 65 degrees and a wind velocity of 25 miles an hour. The surface velocity over a circular shape such as the missile shelter would vary appreciably, resulting in a variation in heat loss from one section to another; however, the heat loss given represents a reasonable average.

A demonstration shelter 40 by 80 feet was heated at a cost of 15 cents an hour to a comfortable temperature when the outside temperature was only 15 degrees above zero.

The inflatable structure is limited as to service life and degree of versatility in meeting special requirements. For example: holes in the skin could put excessive demands on the blower and, if large enough, could cause collapse. However, most types of impact would not pierce the skin because the force would be distributed over a large area. The skin can only be pierced by very sharp objects.

ONE unique aspect of the inflatable shelter is that air is used as a structural element. Actually the pressure is so slight as to be imperceptible to individuals inside; however, it must be pointed out that the reliability of the blower is a critical point in the success of this type of structure. As a result of this requirement, the inflatable shelter has met with resistance in many quarters, but there is no reason to believe that securing the necessary reliability from the blower poses insurmountable or even particularly difficult technical problems.

The air-inflatable type really comes into its own in the case of the vertical shelter. Where horizontal structures are concerned, the air-inflatable is competitive but does not offer substantial savings. As the vertical dimension becomes greater with respect to the base, the inflatable structure becomes a good solution and in some instances the only practical one.

Vertical storage of modern missiles, which can exceed sixty feet in height, is the most perplexing problem. While eliminating the need for a launcher which brings the bird from a horizontal position to a vertical position immediately before firing, vertical storage necessitates the construction of a tower which provides a complete enclosure for the missile.

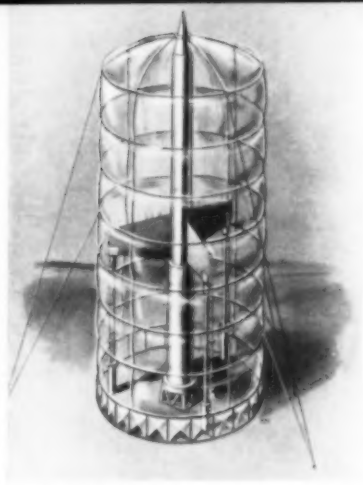

Fig. 1. Air-inflated shelter especially useful for vertically stored weapons.

Framed towers sixty feet high as used for oil-drilling apparatus, radio transmission, telephone wires, etc., are exceedingly expensive due to the high wind moments to be resisted and ice build-up on the structural members. This is true even though the wind is free to pass through the open spaces between members in a framed tower. In the case of an enclosed tower, a solid wall surface is presented to the wind, thereby increasing the wind moment and necessitating a corresponding strengthening of structural members.

In some instances the cost becomes so prohibitive as almost to eliminate the possibility of vertical storage altogether. This is not a problem with the inflatable structure because the internal pressure distribution resists the external force and can be deformed by it without damage.

THE third type of shelter utilizes a frame and nonstructural skin. This technique coincides best with our normal conceptions of shelter design. In their most common form these shelters make use of the conventional architectural principles of post, lintel, truss, and arch. Structures of this type have been in use for centuries.

The Quonset hut performed excellently during World War II, and variations of this design are in wide use today. Manufacturing and construction techniques have become so standardized that buildings of this sort can be inexpensively produced and easily erected.

Progress in this area has largely taken the form of more standardization of components, more efficient manufacturing, and use of novel construction materials.

Since the skin is nonstructural, considerable latitude in the skin material is possible. An example is the use of fabric over a structural framework. Another type makes use of external steel framing with catenary cables strung between them to provide support for a fabric enclosure.

Generally these structures afford better protection than either the blanket or the inflatable structure. Greater flexibility is possible, but costs are proportionately higher than for either of the other types.

ONE type which has come into prominence during the last few years involves the use of a structural skin. The egg shell and sea shell are common natural manifestations of the principle. The skin itself embodies the supporting framework. The inherent advantages of this system are simplicity and interchangeability of parts and an interior space that is not broken by framing. Since the component types are few in number, mass production is possible.

Plastic, thin concrete, and corrugated steel all have been embodied in structures of this type. Physically these structures have a domelike appearance, at least in one elevation. (Fig. 2.)

The price of the structure, in erected form, is much lower than a comparable one composed of a structural frame and nonstructural skin.

We consider the structural-skin type shelter one of the most interesting of the new techniques. During the last several years a number of successful commercial buildings have been erected using this method.

A variation in this concept is one known as the "Gravilift" system. (Fig. 3.) In this design the missile is stored in horizontal position with the combined center of gravity of the missile and launcher aft of the pivot point. At the time of launch the missile pivots to a vertical position by means of gravity. Because gravity is the prime mover, all that is needed is a small commercial motor to control the rate of lift.

The system is partly below and partly above ground. This means that it avoids the costly excavation needed for completely underground systems and also the costly hydraulic systems necessary to erect the bird when the system is completely above ground.

To a certain degree the same launcher can be adapted for use with different types of birds by adding or removing weights from the launcher to give the desired position for the center of gravity.

The normal launcher position is horizontal. This is of tremendous assistance in servicing and checking out the bird.

The Gravilift shelter is of novel design, consisting of telescoping sections. In closed position the shelter resembles a half cylinder. At the time of launch, the sections of the cylinder that are over the bird retract on rails, completely exposing the bird and launcher. This feature permits a very close fit between the shelter and the bird. Many current missile designs call for environmental conditioning, and "contour fitting," because it results in less atmosphere to control, represents a very desirable shelter attribute. Small standard heating and ventilating units can be used.

In retracted position, the entire bird and missile combination is exposed, facilitating servicing and checkout.

THE shelter employs the trussless, structural-skin type construction with its attendant advantages. The corrugated sheet steel is inexpensive. Erection does not require overhead cranes—simple scaffolding is sufficient. Insulation can be easily sprayed on the under sides of the panels. The rails on which the shelter sections retract are completely covered when the shelter is in the closed position.

One point about the excavation of the site deserves mention. The shelter area is surrounded by an earth barricade. To produce this barricade, it is merely necessary to remove the earth from the shelter-launcher excavation and use it to form the embankment. Using the excavated earth in this way provides important savings.

The construction of the so-called "hard-protected" shelter is a new and highly complex field of study. Generally, very little is known about many of the problems attendant in this type of structure. It is currently being studied in connection with the protection for ICBM installations and some fighter squadron bases.

The launcher complex must be designed to withstand all effects produced by the proximate detonation of a nuclear device. In addition, the complex design should be such that the effects produced by the shock wave, thermal radiation, and ionizing radiation will not render the system inoperative immediately following a burst.

The problems of unusual ground shock and the attenuation effects of different soils form an important phase of study necessary to predict shelter survival. The problems of high thermal shock exposure, and radioactive fallout, producing dosage at a fatal rate to the stationed personnel, also must be resolved.

Other problems such as the disposal of blast gases, and determination of site location with favorable geological structure and meteorological conditions, must be given careful consideration. Unfortunately most of the problems cannot be resolved until more empirical data is made available to engineers.

It is appropriate now to consider a specific shelter problem. The shelter shown in Figure 2 resembles a Quonset hut with a series of deeply convoluted curved sections. This design exemplifies many of the problems which have been described. For purposes of discussion and analysis, the requirements involved in this shelter can be broken down as follows: fabrication, system reliability, air transportability, ease of maintenance and repair, and, last but not least, cost. The means by which these requirements were met in this particular design may be of interest.

A number of considerations relate to fabrication. Availability of materials is one of these. Ideally a shelter should be constructed of materials that are inexpensive and in plentiful supply. In the area of steel construction, rolled sections such as I-beams are expensive and difficult to obtain. Light-gauge sheet metal is, however, nearly always available. The solution was the extensive use of deeply convoluted sheet metal mentioned earlier.

The importance of ease of erection has been mentioned. Generally speaking, it is desirable to avoid the use of specially trained men and specialized construction tools. This was accomplished by having all sections similar and simply bolted throughout so there is no need to perform any welding operation in the field.

SITE preparation can be an expensive, time-consuming job. In the instance at hand only the minimum preparation is necessary. In effect, only simple troughs for the footings would be required. It is particularly desirable to avoid deep, expensive excavations. In this instance, the excavation has been kept very shallow.

All difficult fabrication should be performed in the factory. In the case at hand, air transportability was a must, and prefabricated sections had to be such as to fit into the standard space in cargo aircraft. Actually, since a structural skin is used, both the skin and the framework are, in effect, fabricated in the factory.

The advantage of this is readily apparent when this type of structure with its structural skin is compared with a conventional building which requires separate erection of the framework and the later attachment of the skin. The lintel, which is the only construction member above the door, is prefabricated. The door itself is prefabricated.

Fig. 2. Constructed without framework and with deeply convoluted structural skin, this shelter has counterweighted door moving around trunnion.

Modular construction adaptability is particularly important in a missile shelter. The structure will, in all probability, be assembled by unskilled personnel in the field, and to make their job easy the maximum number of parts have been made interchangeable.

Door reliability is one of the most significant requirements of a missile shelter. In the shelter shown in Figure 2, the door operates on a trunnion. It is counterweighted and moves upward to open in a path that is roughly parallel or concentric with the curved skin. Since the door is counterweighted, only a very small force is needed to open it. This force is supplied by a small electric motor, but under emergency conditions the door could be opened by hand.

An important point is that the door is completely isolated from the structure itself. This means that neither opening and closing or wind loads place a strain on the structural elements. Since the trunnion is inside the building, it is not affected by accumulated ice or snow.

THE treatment of the egress door in a framed, nonstructural-skin shelter offers an interesting comparison. In this shed structure, the door is hinged at the bottom. It drops by gravity. Since the door has a steep slope in the closed position, it has the advantage of not allowing accumulation of snow. However, the hinge itself is exposed and is subject to ice jamming, expansion, and rust. A very strong crosspiece is necessary to support the door. The door is twenty by thirty feet, and when it falls it places tremendous strain not only on the crosspiece but also on the whole structure. If accidentally released it could very well be a hazard to personnel.

Modular construction capabilities of the design have been mentioned. Nearly all the sheets are of the same size. These sheets are curved and lend themselves ideally to nesting aboard an aircraft. For air transportability, standard sizes for cargo aircraft were considered the maximum possible dimensions. Actually, in the arch roof design, only with the lintel, the member immediately above the door, is there any need to approach the maximum length of thirty-six feet.

The missile concerned uses a zero-length launcher. This means that the interior of the structure will be subjected to the destructive action of both jet and booster blasts. Very early in the study, before any individual concepts were examined, a thorough inquiry into these matters was undertaken. Charts showing isothermic cones were drawn to indicate the nature of the blast-temperature patterns. The nature and dimensions of the shelter were arrived at as a result of these studies.

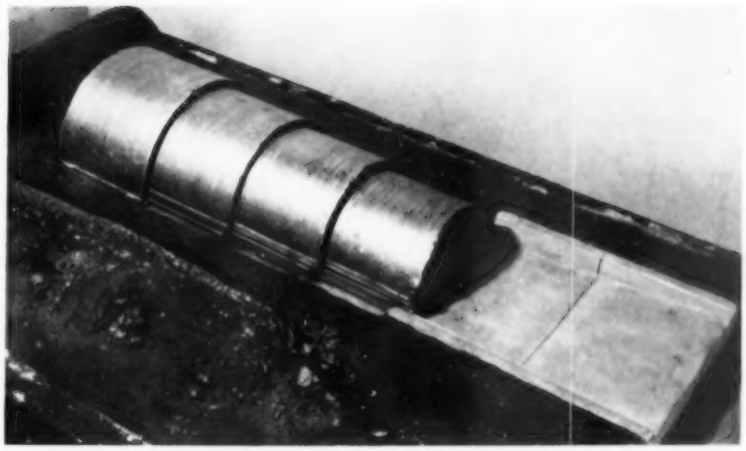

Fig. 3. The "Gravilift" system involves new ideas both in shelter construction and in means of elevating the missile for firing.

Ease of maintenance and repair is an important matter to the men in the field. In the structural-skin concept, no particular maintenance attention is needed. The panels are merely bolted together, and, since all panels are alike, replacement is easy and direct.

A further element is the need for access to install the booster. In this case the back door not only provides for the release of exhaust gases but also permits ready access for booster dollies. Actually the over-all shape of the structure was determined by the dimensions and attitude of the missile during testing and operation. Clearances around the missile during servicing, storage, and operation, were the major factor in determining the shape and size of the shelter.

Also a part of design is the matter of fail-safe operation. The door, the means of egress of the bird, is most concerned here. The door of the structural-skin type shelter is fail-safe due to proper counterbalancing, and very little force is needed to open it.

The problem of sealing is not a simple one because there are many nuts and bolts and joining points at the edges of the curved sheets which require sealing. To solve this problem, gaskets are used in each case. A small neoprene washer is screwed down between the head of the bolt and the sheet. A seal is also placed at the edges of every plate. This is done when the missile shelter is manufactured and does not in any way complicate the assembly of the shelter.

IT has been mentioned that cost exercises a final discipline over the shelter concept. The prime consideration is to provide basic shelter at a minimum cost. It is appropriate at this point to discuss the actual status of the structural skin structure by comparison with other types of structures. The simplest and least expensive type of shelter is the commercial garage. It is actually in the business of providing basic shelter.

The cost of such a structure averages a minimum of $5.50 per square foot. The cost for domestic architecture varies widely, but a figure of $12 to $16 per square foot represents a realistic spread. For industrial buildings, a comparable average figure is $14 to $20 per square foot.

The cost of the structural-skin shelter is somewhat less than $2 a square foot for the shell. The structure as it would stand completed, including the door and door mechanism, would cost about $3.50 to $4 per square foot on a production basis.

The American missile program is past the honeymoon phase. This family, like so many others, has a housing problem. If the marriage is to be successful, the cost of the shelter must be kept to a reasonable proportion of the family's living expenses.

Production Engineering

Research and development for mass manufacture represents a most important link in the chain of events which brings to bear the many functions of the Ordnance system to arm our troops economically

Harry L. Gerwin

THE author has often been asked: What is production engineering and why is it necessary? The answers vary depending on whether one is talking about production engineering in the Army, Air Force, Navy, or commercial practice. Because of this variation, this paper is limited to a discussion of production engineering of fuzes in the Army Ordnance Corps.

As a point of departure, the following definition of production engineering, commonly expressed in Army Ordnance as "engineering for production," is given: Engineering for production is that activity of engineering which, by the application of recognized accepted engineering practices, translates a research and development design release item into an item that can be procured economically and reliably by the national procurement and production headquarters.

Since engineering for production is in essence preparation for procurement, a brief outline of the procurement process is needed before discussing the what and why of production engineering.

ALL Army Ordnance procurement, from nuts and bolts to tanks and missiles, is conducted through Ordnance districts strategically located throughout the United States. Procurement is on a competitive basis with the low acceptable bidder being awarded the contract. The following example illustrates the procedure used:

A decision is reached that X number of fuzes will be procured. The Ordnance Ammunition Command (OAC), Joliet, Ill., receives instructions to procure X number of fuzes. OAC requests that the appropriate Ordnance districts obtain bids from contractors for the fuzes. After all the bids are submitted, they are opened and the contractor selected. The Ordnance district then signs the contract with the contractor and the fuze procurement is under way.

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As the manufacturer produces the fuzes, they are inspected for compliance with the requirements set forth in the inspection procedure by the district inspection representative who either accepts or rejects the fuzes. Acceptance of the fuzes by the inspector constitutes fulfillment of the contract obligation, and the contractor is paid.

This procedure appears very simple, except that there are three obvious questions: (1) How does the procurement agency assure itself that all contractors bid on an exactly equitable basis? (2) How does the procurement agency assure itself that the contractor delivers a good product that operates as intended in its end usage? (3) How does the procurement agency assure itself that inspection for acceptance (a very important factor to both the contractor and the Government) is the same regardless of by whom or where conducted?

The answer to these three questions is contained in a contract instrument known as a technical data package, or procurement package. It provides the necessary information for potential contractors to bid on an equitable basis and for the successful bidder to manufacture the item. It provides uniform quality-assurance provisions so that regardless of whether Army, Navy, or Air Force inspectors perform the inspection, or where the inspection is performed, the criteria for acceptance are the same.

THE procurement package is the principal end product of an engineering for production program but by no means the only one. Engineering for production can be divided into three principal areas of activity: Procurement package engineering, product and process engineering, and, when required, interim procurement.

As previously stated, before an item can be procured competitively (*i.e.*, contractors bid on an equitable basis to deliver a uniform product to a uniform set of acceptance criteria) a procurement package must exist. Such a package consists of: (1) Purchase description, including product requirements and quality-assurance provisions, (2) Ordnance drawings, (3) preliminary description of manufacture, (4) inspection system, and (5) security requirements check list.

Probably the most important element of the procurement package is the purchase description, which must meet two

conditions. First, when procured according to the purchase description, the fuzes should function with the required reliability in the field; and, secondly, the product requirements and the quality-assurance provisions (specifications and inspection acceptance criteria) of the purchase description must be such that a competent industrial manufacturer is able to manufacture acceptable fuzes.

TO meet the first condition that, when the manufacturer meets the quality-assurance provisions of the purchase description the fuze will function with the required reliability in service use, acceptance test procedures and quality-assurance provisions must be developed which do in fact provide for accepting only fuzes that will perform with the required reliability in the field.

The foundation for these acceptance tests and quality-assurance provisions must be parameters which reflect proper fuze performance in service. At the beginning of a production engineering program, the only source of these test parameters is the previous research and development program. Usually, the data developed during research and development are adequate to establish the basic test parameters needed by production engineering.

Once the basic test parameters are established, the next step is to develop them into acceptance-test procedures and quality-assurance provisions which are completely adequate for execution through the Ordnance District which performs the procurement. For each test parameter a definite set of inspection limits must be made available for inspection decisions.

The establishment of these limits and the development and standardization of test equipment to make these measurements are the principal problems of the procurement package engineer once all the basic test parameters have been determined.

The test procedures and test equipment that are developed must measure characteristics which adequately reflect the basic test parameter. The measurement must be sufficiently clear and specific so that any contractor or inspector performing the same inspection will arrive at the same results.

The written documents constituting the purchase description must be clear and concise so there are no misunderstandings or misinterpretations. To assure reliability in this respect, a final draft of the purchase description should be tried on a small scale through a fixed-price procurement, if possible.

If industry already has the know-how to produce a fuze according to the research and development design, the problems associated with meeting the second condition of a good purchase description usually are not too difficult. When this is not the case it becomes necessary either to reëngineer the design to improve the producibility, to develop the necessary know-how in industry, or to use a combination of these two solutions so a purchase description can be written which will meet the second condition.

Sometimes this know-how in industry exists as a trade secret, not available to the Government. While it is not necessary that the Government know these secrets, it is necessary that production competence exist in more than one plant or company to provide both competition and dispersal of plants.

The second element to be considered in the procurement package is the Ordnance drawings. Ordnance drawings, as the name implies, are drawings made to the Army Ordnance format. This format provides the standardization of drawings necessary to efficient handling, reproduction, and storage of such drawings.

Ordnance drawings fall into two categories—mandatory or advisory.

The third element to be considered is the preliminary description of manufacture. The preliminary description of manufacture is normally advisory in nature. It consists of a collection of documents, such as process sheets, bills of materials, flow charts, manufacturing drawings, and procedures which show how an acceptable item was manufactured once. Its principal advantage rests in its value to a potential contractor as a reference in preparing a bid proposal and later to the successful contractor as a technical aid in getting into production quickly and efficiently.

THE fourth element is the inspection system which includes the drawings and specifications for test equipment. The fundamental element in the design of an inspection system or of inspection equipment is the basic test parameter previously discussed. Once all the basic test parameters—limits, tolerances, acceptance quality levels, defect classifications—are established and validated, the inspection system can be designed and appropriate inspection equipment developed.

If it is properly designed around sound test parameters and properly administered, the inspection system will provide for acceptance only of fuzes of the required quality. The design of the inspection equipment must be such that, without sacrificing quality of product, it takes a minimum of time to complete an acceptance test, is simple and cheap to operate, is easy to maintain and calibrate, will retain its calibration for a long period, and should be as fail-safe as possible.

Fail-safe inspection equipment requires that it be designed in such a way that, if failure occurs in the inspection equipment, it will not cause the acceptance of poor quality fuzes.

The fifth and final element in the procurement package is the security requirements check list. This list serves to classify properly all features of the program at the correct security level.

THIS might all be summed up now in a definition of a *good* procurement package; namely, one that specifies product requirments and quality assurance provisions which, when effectively administered, permit procurement of a satisfactory fuze for its end application through the Ordnance district system.

The types of problems which arise with a poor procurement package are:

1. A manufacturer may produce a fuze or component which is accepted according to the quality-assurance provisions of the purchase description. After acceptance, it is found that the product will not perform as required in its end application. The fault lies with the purchase description, not with the manufacturer.

2. A manufacturer has difficulty producing an item, and waivers are granted. The fault may be with the purchase description, or the manufacturer may be incompetent, or a combination of both.

3. The inspection is breaking down and defective material is being procured. The fault may be caused by an unsatisfactory inspection system or inadequate administration of the inspection system, or a combination of both.

Once a good procurement package is available, three distinct advantages have

been achieved. The first has been stated before—the item becomes procurable. The second and probably most important one is that competition can then be introduced into the procurement activity. The advantage of competition, of course, is that it represents one of the strongest management tools available in reducing procurement costs and saving the taxpayers' money.

The third advantage is the development of a broader mobilization base. Complete up-to-date procurement packages are stored at a number of locations throughout the United States. In case of an attack by an enemy, it is not likely that all the packages would be destroyed, and a basis for mobilization would be available in the information contained in the procurement packages that are left.

The second activity of production engineering—product and process engineering—is that engineering which is done to minimize costs, lead time, production time, and requirements for critical materials and manpower. This activity normally is pursued in parallel with the procurement package engineering.

PRODUCT engineering is engineering effort applied to the item itself. Examples are: tolerance studies, standardization of parts such as screws and rods, and reëngineering of parts to facilitate process engineering. Product engineering is begun during the research and development phase as soon as the design has the possibility or can serve as a model for production. It is conducted throughout the rest of the R&D phase, throughout the production-engineering phase, throughout production, and, in some cases, even after the item has been produced.

Process engineering, in contrast, has the same objectives, but it is accomplished by improving processes utilized to manufacture the item, such as improved tooling, reduction of machining required by using extruded stock, and mechanization. Process engineering also may be initiated during the research and development phase, but usually to a lesser extent than product engineering. Process engineering continues during production engineering and during production.

The advantages of product and process engineering are apparent since these efforts are aimed directly at getting the most for the taxpayers' money. In fact, the determination of how much effort to expend in this area is usually easy to make because both cost of the effort and the savings per unit fuze, if the effort is successful, can be estimated with a fair degree of accuracy. With these estimates, and knowledge of the contemplated production volume, the over-all saving or loss can be estimated closely and a decision easily reached.

INTERIM procurement, the third area of activity now conducted by production engineers, is becoming increasingly important in fuzes for guided missiles and rockets. This activity is best understood by stating the problem that created it: What is to be done if a new fuze being released from research and development is so effective or of such importance to our national defense that it should be made available to our field forces at the earliest possible time?

To achieve this end, the expedient of procurement through a special procurement team is utilized. This team, normally composed of both production and development engineers, is given the authority to direct the fabrication and is charged with the responsibility of providing good fuzes to the field. As the program progresses, development engineers are phased out until finally the team is composed entirely of production engineers.

The above procedure provides, on a continuous basis, the engineering know-how to direct fabrication and to inspect and accept with the highest assurance that good fuzes will go to the field while the procurement package engineering and the product and process engineering are being conducted.

The unit cost of fuzes purchased before the procurement package is available, and before cost-reduction engineering is conducted, is bound to be high, but this high cost is overbalanced by such factors as earlier availability of the fuze, thus improving the effectiveness of national defense. It also allows, at an earlier date, discontinuance of procurement of other items or fuzes which become obsolete with the standardization of the new fuze.

To be able to deliver fuzes immediately after release to production engineering, the production-engineering activity must parallel the latter stages of the research and development program. Problems arise when two different activities must function so closely. The production engineer must have a frozen design if he is to manufacture the item successfully.

The development engineer is reluctant to freeze the design because he is then precluded from introducing further improvements or making changes when additional tests and evaluations indicate changes are desirable.

The answer to this problem lies in the application of a progressive system of freezing. For example, there are many components or subassemblies within a fuze, such as castings or machined parts, which are finalized in design very early in the research and development program. As such items are finalized, they can be frozen in design by R&D.

The production engineer then has a frozen design on components or subassemblies which he can release for manufacture. Once a design is frozen by research and development it will not be changed without the concurrence of the production engineer; but by the same token, R&D can and, if experience is a good guide, will have to make changes. The component or subassembly freeze system is a calculated-risk system, and occasionally the results will be negative.

Problems such as those enumerated above will occur when interim procurement overlaps the latter stages of research and development. It must be recognized and accepted that they will occur, but when the coördination between research and development personnel and production engineering personnel is of the highest caliber, the cost and delays which are so often associated with these problems will be kept to a minimum.

THE objective of the Army is to deter aggression but, if it occurs, then to defeat it. To accomplish this objective, the fighting soldier must be armed with the best weapons and Ordnance equipment. It can be seen that engineering for production (procurement package engineering, product and process engineering, and, when required, interim procurement) represents a most important link in the chain of events which brings to bear the many functions of the vast Ordnance system to arm our fighting men at the least cost to the taxpayer.

Technical Competency

Trained procurement personnel of high quality are the only really effective means of determining the ability of a manufacturer to complete successfully a specific contract to supply military items

C. A. Macris

MUCH of the procurement handled by the technical branches of the Navy Bureau of Ordnance is for the manufacture of items requiring ordinary facilities and skills common to American industry at large. There are some items, however, for which consideration of technical competency of the manufacturer is of greater concern than cost or delivery schedules.

Prices and schedules easily lend themselves to analysis, but technical competency to create a design, to perform engineering services, or to manufacture an item is not so easily ascertained.

How then can the Bureau, in the solicitation of bids, ensure replies with a common denominator so that a reasonable evaluation and determination of the technical competency of the bidder may be made in comparison with other bidders of near equal ability? What standards for the measure of technical competence can be developed?

IN order that the sources of the problem may be fully understood, it is necessary to understand the current procurement regulations, procedures, practices, and conditions.

Current Government policies and practices provide two principal methods of procurement: formal advertising and negotiation.

Basically, it is the Government's policy to procure all supplies and services by formal advertising. Procurement may be effected, however, by negotiation when such method is justified and approved by proper authority under one of the exceptions permitted by Title 10 USC 2304a.

This article is based on a report to members of the A.O.A. Mine Committee for consideration prior to a recent meeting of the Underwater Ordnance Division in Washington, D. C. Mr. Macris, Ordnance Ammunition Command, Joliet, Ill., was chairman of the committee assigned to draft the report. Other members of his committee were: F. D. Friedlein, R. L. Glover, W. S. Leitch, and R. W. Robbins.

The decision as to whether a particular requirement should be procured by formal advertising or by negotiation depends on the nature of the item and the related procurement circumstances. As a general rule, procurement by formal advertising is effected when (1) definitive specifications and drawings are available; (2) there is sufficient time for the formalities incident to this method (*e.g.*, advertising, receipt, opening, and evaluation of bids); and (3) an adequate number of responsible suppliers are expected to submit bids.

When procurement by formal advertising is not considered appropriate under the circumstances it is necessary to justify and obtain authority to negotiate under one of the exceptions permitting negotiation provided by Title 10 USC 2304a.

Approval for negotiated procurement is obtainable only outside the Bureau of Ordnance, and under certain circumstances approval by the Secretary of the Navy is required. The difficulties involved in justifying negotiated procurement resolve the situation to the simple fact that Government procurement normally falls into two basic categories:

1. *The Procurement of Unclassified Items.*—Procurement of such items is normally required to be accomplished by formal advertised bidding. Any manufacturer is eligible to submit a bid under this procurement procedure.

2. *Procurement of Items Under Security Classification.*—For such items, solicitations for bid are made to a selected list of manufacturers who are judged by the Bureau of Ordnance to be, in general, both financially and technically capable and responsible. In some instances, other manufacturers showing evidence only of security clearance may acquire invitations to bid. Even under these circumstances, in many instances the procurement may be classified as "limited" negotiation.

FOR a clear understanding as to the meaning of such contracting terms as "invitations," "bids," "proposals," etc., and their interrelationship with certain other contracting terms, see Table 1.

A bidder or offeror whose bid or proposal is within range for further consideration for award of the contract is often referred to as a "prospective contractor."

Upon receipt of bids (or proposals, in

the case of negotiated procurement), it is the contracting officer's function to establish, first, whether or not the lowest priced bid is "responsive"; *i.e.*, that such bid conforms and agrees with every provision of the invitation for bid in all respects and that no qualifying conditions are stipulated by the bidder or offeror; and, secondly, that the bidder or offeror is "responsible."

A "responsible" prospective contractor is one who, according to the best information available, meets all of the requirements set forth below:

(1) Is a manufacturer, construction contractor, or regular dealer; (2) has adequate financial resources or ability to secure such resources; (3) has the necessary experience, organization, and technical qualifications and has or can acquire the necessary facilities (including probable subcontractor arrangements) to perform the proposed contract; (4) is able to comply with the required delivery or performance schedule, taking into consideration all existing business commitments; (5) has a satisfactory record of performance, integrity, judgment, and skills; and (6) is otherwise qualified and eligible to receive an award under applicable laws and regulations.

IN making the determination as to whether a bidder is responsible, the contracting officer is guided by such procurement history as may be available on the prospective contractor; standard financial publication; industrial production capability records; Dun & Bradstreet credit reports; and by information which he may solicit from the technical sections of the Navy Bureau of Ordnance and from the naval inspectors in respect to "technical competency" and other aspects concerning the prospective contractor's ability to perform the contract.

The Naval Material Inspection Service is available to the contracting officer to prepare, at his request, general-purpose facility surveys and preaward surveys to establish the status of a contractor, either on a general basis for inclusion in bidders' lists, or in connection with a specific item of procurement.

Chapter 2 of Material Inspection Service, U.S.N. Administration Manual, sets forth in a most adequate manner the procedures and general considerations involved in the preparation of such surveys. Examination of the contents of this chapter results in the impression that the inspector to execute this function properly must be:

1. Thoroughly capable to examine and analyze the financial structure and the financial and accounting practices and reports of various sizes and types of business enterprises.

2. An expert in the interpretation of organizational structures and their effect on performance.

3. A competent industrial engineer to evaluate the technical capabilities of an organization.

4. Thoroughly conversant with all the details and specifications of the item under procurement, in the case of preaward surveys.

Assuming that the inspector is qualified in all these respects, the very volume of work, and the natural reluctance of inspectors to disqualify concerns in their respective areas, make this approach at determining contractor eligibility not altogether reliable.

Concerns which are potential bidders vary considerably in motivation, attitude, and sincerity, as they do in financial capability and technical competency. With respect to motivation, attitude, and sincerity, bidders fall someplace within the limits of the following general classifications:

1. The competent, ethical bidder who submits a conforming bid, consistent with his normal practices, with the full intention of complying with all provisions in accordance with the terms of his proposal.

2. The less-competent bidder who innocently submits a bid without full evaluation and realization of the complexities of the procurement in question.

3. The bidder who knowingly bids low to secure an award, and takes a calculated risk on (a) the issuance of changes in specifications and his ability to negotiate a more favorable over-all contract price on the basis of such changes; and (b) urgent requirements for the item under procurement and other factors which may induce the Government to adjust the original bid to his advantage.

FROM the above factors, and many others which defy generalization, it is obvious that Government procurement has become a complex, time-consuming, talent-consuming, and, in many instances, uneconomical process. Although the specific objective of this study is to provide the contracting officer with improved data and methods which will assist him in his determination of the "technical competency" of each bidder, *the basic objective is to ensure the expeditious and economical production of the materials required by the Government, through the effective utilization of the resources of industry.*

TO achieve these objectives, it is necessary to: (1) minimize unqualified bidding by assisting bidders (to the extent possible within the limits of fair procurement practices) to evaluate their capabilities with respect to individual projects; (2) eliminate the losses to industry and the Government resulting from promiscuous bidding; and (3) reduce the effort necessary on the part of the Government in disqualifying unqualified bidders.

Advertised procurement appears to have the advantages of generating greater competition which may theoretically result in lower costs to the Government; offering equal opportunity to all strata of industry; eliminating the possibility of collusion; and obviating the necessity for the exercise of judgment on the part of the buyer.

However, security classification, or the lack thereof, should not alone be the basis for resorting to advertised procurement. For such procurement, a military item must be stable in design; its specifications must be complete, realistic and honest; and the time limitations for its production not too exacting. Even under the most auspicious circumstances, advertised bidding has many inherent disadvantages.

The reduction in advertised procurement would tend to reduce, at least in volume, the problem of determining the technical competency of bidders. Procurement by negotiation should not reduce competition but may stimulate it by introducing a nearly common denominator. This method of procurement normally should result in greater economy to the Government and industry, and the process of negotiation should be an invaluable aid in partly determining the prospective contractors' technical competency.

Further, through this process, technical contributions to design and manufacturing methods by the contractors are possible and normally result from the discussion and analysis of prospec-

tive contractors' proposals. This method of procurement obviously places a *premium on the judgment of Government procurement personnel and requires competency on a par with that of their industrial counterparts.*

This in itself is an advantage, since it results in the development of more competent, stimulated Government procurement organizations, capable, under proper management controls, to handle the world's largest procurement job.

Regardless of the method of procurement employed, the evaluation of the "technical competency" of a prospective contractor successfully to complete a specific contract to supply military items is of paramount importance.

The initial reaction of the Mine Committee was to provide standards and, as nearly as possible, mechanical means for the measurement of "competency." To do this, "competency" was construed to consist of the following basic elements: (1) General attitude—the spiritual quality; (2) Technical and production resources; (3) Production know-how, including prior military contract experience; and (4) Capacity—the relation of resources, existing workloads and backlogs, and the proposed contract.

In the development of such standards of measurement for "technical competency," certain basic factors must be taken into consideration.

COMPETENCY must be related to the job to be done; *i.e.*, it is not so much a matter of which bidder (or offeror) is the most competent as of whether the low bidder or offeror has adequate technical competency in relation to the project at hand.

Competency in excess of that adequate for a given project must not form a basis for higher rating with regard to that particular project.

With the above elements and factors in mind, attempts to establish standards of measurement produced the following observations and deductions:

1. Elements of competency such as "general attitude" and "military production know-how," are not reasonably subject to quantitative measurement.

2. Measurements of technical and production resources on an absolute basis are limited in value unless related to over-all tasks, and their relative values change constantly with time.

3. Any media that may be developed would never be accurate enough to justify precise quantitative classification of results; rather, they *should serve only as guides* for the exercise of judgment.

Method of procurement	*Soliciting document*	*The responding company*	*The document submitted by responding company*
Formal advertising	Invitation for bid	Bidder	Bid
Negotiation	Request for proposal	Offeror	Proposal
Negotiation	Request for quotation	Offeror	Proposal

Table 1. Interrelationship of common contracting terms.

It is the opinion of this committee that the determination of "technical competency" cannot be reduced to a mathematical formula or to any mechanical process.

The determination of "technical competency," therefore, always will be predicated on qualified judgment on the part of the procurement agencies, based on effective data and methods, and subject to appropriate management controls.

The implementation of the following recommendations will, in the opinion of the committee, materially assist in reducing the problems revolving about technical competency:

Advertised Procurement.—This form of procurement should be limited to those items which qualify not only because of the lack of security classification but also by meeting all other criteria essential to successful advertised procurement, namely; (1) design completeness and stability; (2) adequate description and complete specifications; (3) availability of many sources with capabilities for item manufacture; and (4) lack of critical or stringent delivery schedules.

Production Engineering.—A sufficient degree of production engineering prior to release of the item to production would eliminate many problems encountered in the manufacture of military items and would disclose and highlight other problems which cannot be eliminated.

Self-Elimination of Prospective Bidders.—Industry in general is made up of objective and ethical concerns—and such concerns are not willing to engage knowingly in enterprises beyond their capabilities. Therefore any method and data which will induce and assist in the self-analysis of prospective bidders will result in the self-elimination of many bidders lacking adequate technical competency. The Government may assist in such self-analysis by any or all of the following methods.

1. *Design Disclosures.*—Design disclosures must be complete and comprehensive and must call attention to critical materials, processes, tolerances, and other factors involved in the manufacture of the item. Where previous ufacture of the item.

2. *Prospective Bidders' Conferences.*—Where a Government procurement agency deems it advantageous to both the Government and industry, prospective bidders' conferences may be made mandatory prior to the submission of bids.

3. *Questionnaires.*—One approach presented for the solution of the technical-competency problem has been the use of questionnaires through which the Government may evaluate the capability of bidders.

THE committee concluded that a combination of two questionnaires would produce an acceptable guide in the determination of technical competency:

1. A "general" type of questionnaire, suitable for all industry and applicable to all military items.

2. A "specific" type of questionnaire dealing with qualifications necessary for a certain "family" of military items.

The "specific" type of questionnaire referred to above may be supplemented by the inclusion of factors pertaining to the item under procurement which the prospective contractor would use as the basis for the preparation of a production analysis chart, sometimes referred to as a "line-of-balance chart."

In conclusion, procurement personnel of high quality, trained to exercise judgment and accept responsibility in their particular fields, are considered as the only really effective means for the determination of technical competency and the successful and economical procurement of military items.

Ordnance Disposal

The identification, inerting, removal, and destruction of deadly devices such as unexploded bombs and missiles requires constant study and training, especially in this day of nuclear weapons

Capt. Henry W. Stupakewicz

TIME was when the wartime contest was one bomb against one city block. Now it is one bomb or missile against one city—period.

In those days, a bomb-disposal man matched wits with mechanical, electrical, or chemical fuzes. Now he pits his skill against these same devices (advanced by fifteen years of technology) and also against fuzes of magnetic induction, piezoelectric, radar, acoustic, or photoelectric design—or any combination of these in series.

Once, knowing the inner workings of 100 fuzes was life insurance. Now, with over 1,000 devices to know, the price of such insurance has risen.

If the bomb-disposal man had a good mechanical background, he once had a great advantage. To have an advantage now, he must be versed in mechanics, electricity, electronics, general physics, chemistry, mathematics—and public speaking!

The day is long past when the bomb-disposal mission was to render bombs safe, and bombs only. Today explosive-disposal organizations render safe any type of ammunition from caliber .22 rifle cartridges to the most complex thermonuclear weapon—ours or foreign.

ALL explosive ordnance which has misfired or is malfunctional, booby-trapped, or deteriorated to a dangerous degree becomes a concern of ED.

With these great changes in the mission, the danger, and the consequences, has the Army organization for dealing with the problem kept pace with the needs? Let's see.

Captain Stupakewicz is currently serving with the 548th Ordnance Detachment, Explosive Disposal Control, The Presidio, Monterey, Calif.

After World War II it was thought that such highly specialized units would have no place in the postwar organization—and for a while this was almost true. But, when dump after dump of enemy ammunition was discovered with no specialists on hand to effect disposal; when booby traps were found effective even after years in place; when soldiers picked up duds for souvenirs and died; when our own stacks of ammunition deteriorated to the point where normal ammunition personnel could not handle the task of disposal; when white phosphorus ammo rusted through and started burning while in the stacks; when caves of ammunition, once blown shut, eroded open again; when bulldozers found, the hard and noisy way, that there were still unexploded ordnance in the rubble—then gradually a demand was created again for the services of Army Bomb Disposal units.

The other services also realized the need, but only the Navy had retained a school and the staff necessary for adequate training of personnel. Use was made of the offered facilities and a new organization was created.

One of the first steps was to change the name to the more inclusive "Explosive Ordnance Disposal" and then, because volunteers were so utterly lacking, incentive pay was created for such duty.

Because the job had grown in scope and because serious questions were constantly arising as to proper service jurisdiction over particular incidents, a series of conferences culminated in a joint regulation on EOD responsibilities (AFR 36-8/OPNAV-INSTR 4027.1A-/AR 755-1300-6). Roughly, the Air Force now performs EOD on airfields only, the Navy on items found in the water or on naval bases, and the Army does the rest (including disposal of nuclear sabotage devices).

THERE are details and fine points, of course, but a secondary responsibility of each service is to assist the others when asked, on the lowest possible echelon. This tends to neutralize the fine print and, in my opinion, has so far been effective.

Within the Army, over-all staff supervision of the explosive ordnance disposal program is exercised by the Chief of Ordnance through a part-time EOD staff officer. An Ordnance explosive disposal officer helps prepare for the Office of the Chief of Ordnance some of the various pertinent EOD policies and carries out other Army-level technical responsibilities.

The Chief Chemical Officer is responsible for effecting staff supervision over disposal of certain chemical ammunition after the explosives have been ren-

dered safe by EOD men, and the Chief of Engineers is responsible for as much of explosive ordnance disposal as pertains to tactically installed and employed high-explosive demolition agents, including land mines and booby traps. These are the only major exceptions to the general rule that EOD men take care of all unexploded ordnance.

At the U. S. Continental Army Command, in the office of the CONARC Ordnance Officer is a hard-pressed EOD staff working at an utterly thankless job—standardizing explosive ordnance disposal policies and procedures among zone of interior armies.

Each zone of interior army has a setup similar to CONARC (an EOD staff officer in the office of the army Ordnance Officer). This, until now, has been a real job—one into which a skilled staff man could sink his teeth effectively and show his mettle quickly. There is still a great deal of improving, revising, and coördinating to do, but the basic plans by this time are pretty well established in each army area.

TO carry out its explosive ordnance disposal program, each U. S. army area has an Ordnance detachment (explosive disposal control) and a number of Ordnance detachments (explosive disposal). These smallest units with the biggest names bear the burden of actual control and disposal of explosives in the field.

A typical army-level EOD program must first of all provide units for EOD service and establish a unified, centralized control. There are as many administrative headaches as there are posts where EOD units are stationed, and the problem of control, therefore, is not a simple one.

Once the units are settled around critical areas, they could remain at their cribbage boards, useless forever, unless reports of unexploded ordnance are received. Part of the army-level EOD program, therefore, is directed at establishing and operating, in conjunction with Civil Defense and military installations, an effective incident-reporting system.

This may sound simple enough, but unless selected personnel are properly trained and unless a simple reporting system is followed, ninety per cent of the reports will be false, and some will never reach EOD at all.

This is not conjecture. I can testify to traveling twenty-two hours in an open jeep, through driving rain, to neutralize a suspicious-looking pair of wires sticking out of the ground in front of a command post. The entire device was a single piece of wire, six inches long, with the loop trampled in the mud and the two ends sticking out of the ground—nothing more!

I also can recall being loudly berated by a senior officer for failing to dispose of a 500-pound bomb in his unit mess area, even though the report had never reached our unit at all.

Incidents of this sort can be laughed off in slack periods or in time of peace; but in an emergency, with EOD personnel in short supply, they assume a different complexion.

Anyway, units in the field generally maintain close liaison with the required agencies, even though the joint regulation which says "in conjunction with" to the Army, is in no way binding on Civil Defense.

Another part of the army-level explosive ordnance disposal program is the requirement that it keep sufficient numbers of fully qualified, adequately trained EOD men in the units. This is never a small matter and has been an item of major concern.

To begin with, the men must volunteer. There is no central procurement or distribution point for EOD volunteers (at least I haven't found one), and therefore prerequisites for volunteers, and the method of processing, vary from one army area to another. The volunteer must survive a most stringent security investigation (up to a year or more in some cases), and he cannot be sent to technical school until the security clearance is granted.

Only after these requirements are met can a man apply for a school quota which will be granted only if the school has spaces available and if the finances in his army area are not suffering from malnutrition. These problems generally pop up at the tail end of a fiscal year or at a change of installation command.

To survive scholastically the man must maintain an average of 85 per cent—not for a week or a month, but for 12 to 18 weeks in a school where instructors are from all services and often use service terminology unfamiliar to the new student. The mark becomes, in addition to a grade, a measure of the student's persistence and dependability, his ability to adapt quickly, and his ability to get along with others—an important quality in a small unit.

APPROXIMATELY every year and a half the man must return for a month and a half of additional training so that his skills are never lost or diminished too severely. If the return is delayed for longer than three years he must take the entire course over, right from scratch. There is no place in the EOD field for technical mistakes.

Up to this point, the man has been training. By the time he takes his accrued leave and goes through a unit training cycle (and becomes of value to the unit)—about two years have elapsed. This is one reason why it is an army-level part of the EOD program. Juggling personnel into and out of school so that no unit is crippled by absences, etc., requires a great deal of coördination.

The army EOD staff officer (generally, in these days of economy, also the commander of the Ordnance Detachment (EDC) when he accomplishes

Uncovered by a construction project, this old impact area in New England was cleared of its possibly dangerous ammunition by Explosive Disposal personnel.

the program listed thus far, busies himself with agreements. There has to be an understanding between the Army and the Air Force or naval units in the area on extending assistance to each other at the lowest possible echelon.

Adjoining Army areas also must be contacted regarding mutual EOD help because there are very few EOD units around. Agreements call for practice, and arrangements continually must be made for participation of other EOD units in maneuvers, tests, and problems. Contact must also be made with law-enforcement agencies and with others regarding investigation of nuclear sabotage devices.

THE Ordnance Detachment (EDC), a control unit, with its two officers and nine enlisted men, implements the army-level EOD program. It is assigned to army, is under control of the army Ordnance Officer, and is responsible for the field work required in the EOD program.

Disposal units (Ordnance Detachments (ED) are under direct operational control of the Ordnance Detachment (EDC). In addition, annual training tests are administered by this control unit to its disposal units because of the extremely technical nature of the test. When a testing team is required to travel as much as 1,000 miles and return—and there are more than a dozen units to test annually—there is a rather considerable expenditure of time involved.

The normal work load is enough to keep the unit busy. But a requirement also exists that EOD training be standardized in the entire army area, and this in turn requires standard lesson plans, training aids, descriptive literature, and student handouts. Liaison with Civil Defense agencies, civil authorities, Federal and State government agencies, and other services is a continuing effort in any EOD control unit. These liaison visits are often followed up by appearances as guest speakers at civic organization meetings. (There's that need I mentioned for a public-speaking ability.)

Any mysterious explosion results in requests for an opinion or identification of fragments or an outright investigation by EOD people. Because officers in a control unit are generally more experienced, such activities often become their lot. Operating instructions, training inspections, and the other normal functions of any supervisory unit also must be taken care of.

Ordnance Detachment (EDC) people have become involved in a limited but complicated technical intelligence program, are equipped to accomplish extensive explosive ordnance reconnaissance, and can perform certain radiation-monitoring functions. There is, to say the least, a great deal to do. The finer points of an effective EOD program must be based on personal experience of the officers concerned, because the available textbooks are few—and out of date. Therefore, a great deal of suggestion, direction, and advice tends to flow from the control unit to disposal units.

The Ordnance Detachment (Explosive Disposal) is assigned to army, is under operational control of the Ordnance Detachment (EDC), and is provided housekeeping and matériel maintenance support by the station at which located. One officer and nine enlisted men are authorized, although most units are operating at reduced strength with seven enlisted men. If the control detachment commander has his hands full, the disposal detachment commander has more.

To begin with, he has enough TOE material to justify his 2½-ton truck and 1½-ton trailer, the ¾-ton truck and ¾-ton trailer, and the ¼-ton truck and trailer. Maintaining these vehicles and equipment under garrison conditions requires about thirty per cent of a unit's time. To keep up the supply records is never less than a full-time job for one man. Unit area maintenance in most cases requires that the men pull details about three times more often than in a company-sized unit.

CHARGE of quarters, stand-by duties, and on-call requirements vary in different army areas. It is a conservative estimate that one night out of two is spent on duty, as an average. In one duty area, the men averaged three out of four nights' duty over a 5-month period. This is normal garrison duty, mind you, and is not concerned with duty overseas or during bonafide disposal operations which generally must be carried on round the clock.

The overhead administrative duties of an Ordnance Detachment (ED), in my opinion, require almost as much time as in an Ordnance Company, but with less than one-fourth the administrative personnel. The EOD supervisor spends about fifty per cent of his time doing first-sergeant work, and the clerk-typist is never, never at a loss as to what he must do.

THE commanding officer is in the peculiar position of being required by Army regulations to carry out personally the final rendering-safe procedures on any incident. This responsibility cannot be redelegated, although he may authorize (but not require) certain enlisted assistants to perform such procedures as are within their capabilities. In view of the potential consequences, this is logical enough, of course.

But one result of this requirement is an officer who is more generally found in fatigues than in service uniform, who has callouses on his hands and unfinished paperwork on his desk, and who is much closer to his men than the C.O. of any unit you care to name. He serves two masters—the one with operational control over him and the one with administrative control.

Inevitably, he finds himself in the middle as to why, as a post officer, he cannot accept additional duty, and why, as an EOD officer, he allows himself to take an additional duty. The discouraging part about this situation is that it repeats itself every time major installation staff officers are changed.

As for operations, his work starts where the control unit stops. Generally, the higher echelon officials are contacted by Control, but the work of contacting local municipal Civil Defense heads, local chiefs of law enforcement, and local liaison with other services is his lot. He needs to contact three times the number of people, but never quite makes it.

The job of actually conducting the instruction of Civil Defense personnel is his—and it takes more than meets the eye. CONARC has stipulated that "the highest standards of instruction, use of vivid training aids, and superior military dress and deportment will be emphasized."

EOD detachments are among the few Army units with an assigned civil responsibility whether there is disaster or not, and a failure to understand this is probably the reason why some installation staff officers show increasing reluctance to extend financial cooperation. But EOD units, although ordered to operate at reduced strength, still must

maintain the same emphasis on the EOR training program, even in these times of reduced appropriations. This money problem is a perennial one and must be re-resolved every time installation staff officers change.

Civil authorities are responsible for disposal of conventional (high-explosive type) sabotage devices, but so few communities have police trained in this work that the Army (to protect itself from being called on such incidents in time of emergency) is coöperating by extending instruction in certain phases of this field to law-enforcement personnel.

In certain instances, when non-Government-owned explosives are involved in fires or accidents, or in truck or train explosions, EOD personnel assist on a reimbursable basis to prevent or alleviate disaster. There are a few legal angles to this function, but it is not necessary to get into them here. I am merely enumerating some of the operations in which a peacetime Explosive Ordnance Disposal unit may find itself involved.

Range clearance is not an EOD function. Installation commanders are told in several regulations to have demolition specialists placed on their local TD, but EOD may assist when the EOD operational and training requirements are fulfilled. In such cases, however, Explosive Ordnance Disposal personnel are used only occasionally, as on big-scale clearance activities.

EOD units can be used, however, for destruction of hazardous stockpile ammunition and to assist the Provost Marshal in cases where knowledge of ammunition or explosives is required.

There are many other instances in which an EOD unit can be useful; for example, furnishing displays of inert ammunition, inerting ammunition items for needed technical intelligence, or setting up explosive training devices.

EOD personnel are not demolition experts. Nowhere in the EOD school curriculum is construction blasting or Engineer-type blasting taught. If EOD personnel show some skill at such tasks it is due to prior personal experience.

An EOD unit is more concerned with technical training than with peacetime operations, although this should not be interpreted as meaning operations won't be carried on. But the immense challenge of keeping up with the increasing number and complexities of ammunition items, guided missiles, and the like; the continued efforts to read up on the latest technical intelligence bulletins; the eternal study and review of electronic systems, mechanical devices, and chemical fuel reactions—all these require more time than can be given to training.

EOD technicians use block and tackle to remove unexploded bomb from its crater.

If I seem to have been justifying EOD all this while, here is where I will take a strong stand. No EOD unit has any business loafing. There is so much technical knowledge to assimilate that every available hour must be devoted to technical training. Units on the defensive will plead security classification (and many times honestly) as a reason for vague training schedules.

I say, let each post send a security-cleared officer to its EOD unit periodically to check whether the unit is, in fact, conducting its required training. There may be just two people involved, but they ought to be working or training. Our units have not been subjected to a great deal of field work, so when old man experience calls, it won't be for a lesson—it will be for an examination. And the passing mark is 100 per cent. Units which neglect their training should be treated in the same manner as other recalcitrants. On this point, there is no weaker stand.

Sixteen years of experience, of trial and error through changing needs and changing times, have matured EOD to the point where it has a definite place in the Ordnance field. Future conflicts will increase the need, because in this nuclear age what commander can afford to ignore an unexploded missile which has landed in his area or can allow a million-dollar dud with a high security classification to fall on enemy lines without making an effort to retrieve it?

With the duties and functions listed so far, and with Army explosive ordnance disposal responsibilities now clearly outlined, it seems to me that EOD, born of the London blitz, is here to stay.

"Explosive-disposal organizations render safe any type of ammunition from caliber .22 rifle cartridges to the most complex thermonuclear weapon—ours or foreign."

Battlefield Illumination

This is an area that only recently has been the subject of serious study, and many improvements can still be made in shells, flares, and searchlights so that night military operations will be more effective

Dr. David Hart

AS small and large wars have occurred, interest in battlefield illumination has increased, and during such periods some urgent attempts have been made to throw more light on the subject. Between wars, however, little or no sustained effort has been made in this direction. The value of battlefield illumination through the use of illuminating shell, searchlights, and flares was proved in World War I.

At the beginning of World War II, illuminating devices were essentially of the same type as those used in the First World War and were suitable for signaling and local illumination only. The need for lighting up the battlefield was emphasized in the North African Campaign, and shell, aircraft flares, and searchlights were reintroduced. Several large land operations were conducted at night in World War II.

During this period there was a limited amount of research and development of improved military pyrotechnics, but this consisted essentially of testing and developing substitute ingredients in flares and other compositions to take the place of shortages of materials as they appeared. Also, some new pyrotechnic items appeared to meet new emergency situations.

IMMEDIATELY after World War II there was very little progress in the development of improved battlefield lighting. Projects to evolve new devices or to secure quantitative data on the actual needs for illumination under battlefield conditions were limited or canceled because of lack of funds. As a result of the action in Korea, interest in battlefield illumination was again revived.

Until his death last June, Dr. Hart was chief of the Pyrotechnics Laboratory, Picatinny Arsenal, Dover, N. J. This article is based on a paper read by Dr. Hart before the meeting of the A.O.A. Bomb Committee held at Chincoteague, Va.

The purpose of battlefield illumination is, of course, to provide sufficient artificial light so that ground operations can be conducted much more effectively at night. As the intensity of artificial illumination approaches that of daylight, it becomes practical to employ daylight tactics and techniques which otherwise cannot be used at night. Proper utilization of illumination allows more effective execution of night offensive and defensive actions, including bombing operations.

In general, two types of lighting are considered for battlefield use:

1. Artificial moonlight, which is illumination of an intensity between that of starlight and that of a full moon on a clear night. The ground illumination under a full moon on a clear night is considered to be 0.025 foot-candle.

2. Artificial daylight, which is illumination of an intensity greater than the light of a full moon or ground illumination greater than 0.025 foot-candle. The optimum illumination is, of course, the equivalent of daylight and corresponds to a ground illumination of 1,500 foot-candles or more.

In view of the lack of adequate information on battlefield illumination despite its importance in night warfare, a comprehensive study in this field was begun in 1951 during the Korean war. A research project was initiated at Picatinny Arsenal leading to optimum parachute illumination flare design, since this was a prime method of obtaining battlefield illumination using stationary, artillery, and aircraft flares.

THE first phase of the project was a study showing the relationship between the various important parameters for parachute illuminating flares, such as intensity of illumination, suspension height, radius of ground illumination, rate of descent, and weight load.

This study was completed in September 1951 and was the first comprehensive theoretical analysis made of this subject. It is now the basis for predicting the performance of parachute flares as well as aiding in setting up new requirements.

It is a well-known fact that the intensity of illumination on an object from a light source varies directly as the intensity of the light source and inversely as the square of the distance of the object from the source. This is expressed by the equation $E = I/d^2$ where I is the intensity of the light source in candles, d is the distance of the object from the light source in feet, and E is

the intensity of illumination on the object in foot-candles.

Imagine a parachute illuminating flare suspended at a height h feet above the ground and at a distance of d feet from the farthest point to be illuminated. The radius of illumination on the ground, therefore, will be r feet. Assuming direct illumination and that all targets are normal or perpendicular to the line of sight from the flare to the ground, the above formula becomes $r^2 + h^2 = I/E$.

Assuming that E equals 0.025 foot-candle at the outer edge of the target area or circle of illumination and plotting the height of the flare against the radius of illumination, Figure 1 is obtained showing the boundaries of 0.025 foot-candle illumination for flares having various intensities.

These curves are applicable for ground observation where the objects to be illuminated, such as tanks, standing troops and the like, are approximately vertical and more or less normal to the parachute illuminating flare.

Table 1 shows the optimum conditions for flare illumination for ground observation where the minimum illumination at the outer edge of the lighted area is 0.025, 0.05, and 0.1 foot-candle, respectively. Inside the circle of illumination the intensity increases to a maximum at the center.

Correction

In the September-October issue of ORDNANCE, *the article, "Rearming at Sea," was credited to Harvey C. Simms. Actually, the article was prepared by Henry Green, supervising engineer at the Naval Ordnance Materials Handling Laboratory, Naval Ammunition Depot, Earle, N. J.*

For the illumination of bombing targets as well as for assessing bomb damage, air observation is involved in which most objects to be illuminated appear essentially horizontal. In particular, those objects near the edge of the illuminated area are not likely to be normal to the flare, and the illumination on them is much less than on those which are normal. In such cases the cosine law holds and the equation is

$$E = I/d^2 \cos \theta$$

From this we obtain the equation

$$E^2 = \frac{I^2 h^2}{(r^2 + h^2)^3}$$

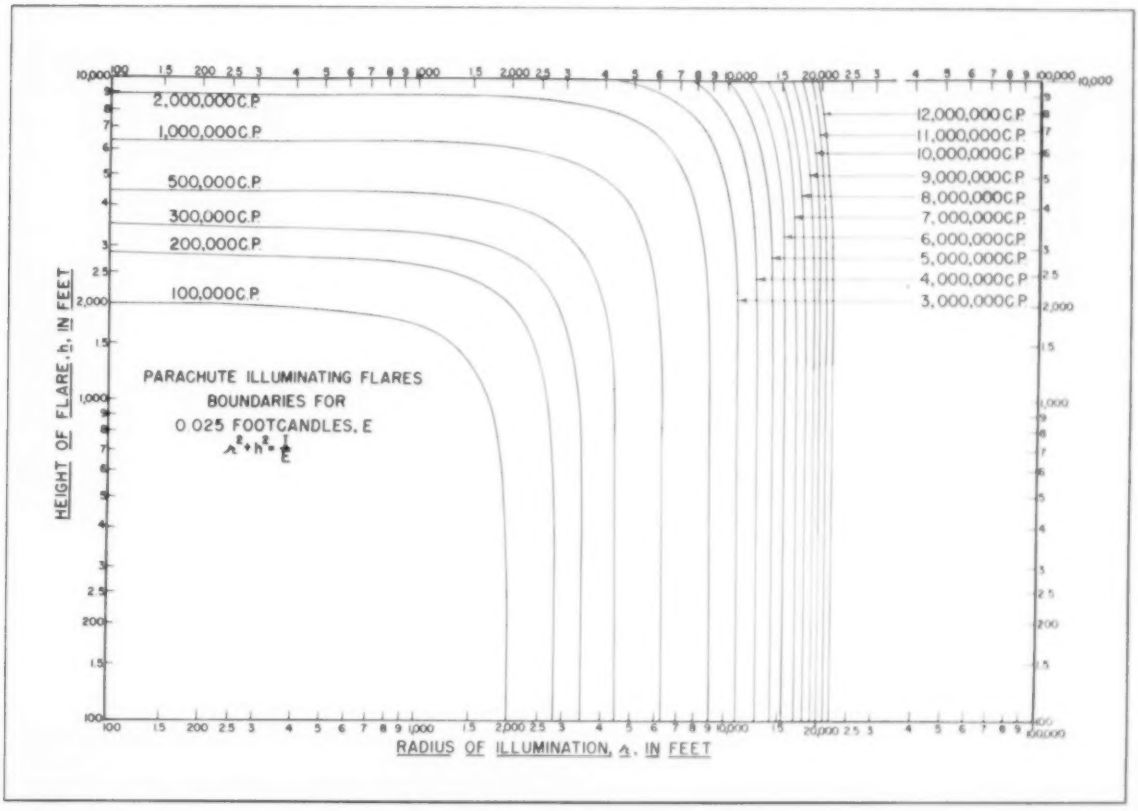
Again assuming $E = 0.025$ foot-candle illumination at the periphery of the target area, we can chart the curves obtained for flares of various intensities.

The optimum conditions for flare illumination for air observation where the minimum illumination at the outer edge of the lighted area is 0.025, 0.05, and 0.1 foot-candle, respectively, are given in Table 2.

Inside the circle of illumination the intensity increases to a maximum at the center. It is interesting to compare the illumination values obtained under both conditions for a flare having a rated candlepower of one million, as shown in Table 3.

The values in Table 2 are probably

Fig. 1. Boundaries of 0.025 foot-candle illumination for flares having various intensities.



Direct Illumination $r^2 + h^2 = \frac{I}{E}$

Average CP 10^6 candles	*0.025 foot-candles*		*0.05 foot-candles*		*0.1 foot-candles*	
	Optimum radius (feet)	*Optimum height range (feet)*	*Optimum radius (feet)*	*Optimum height range (feet)*	*Optimum radius (feet)*	*Optimum height range (feet)*
0.1	1500	0– 1300	1000	0– 1000	600	0– 800
0.2	2500	0– 1400	1500	0– 1300	1000	0–1000
0.3	3000	0– 1700	2000	0– 1400	1500	0– 900
0.5	4000	0– 2000	2500	0– 2000	2000	0–1000
1.0	5000	0– 4000	4000	0– 2000	2500	0–2000
2.0	7000	0– 5500	5000	0– 4000	3000	0–3300
5.0	10000	0–10000	9000	0– 4500	5000	0–5000
10.0	17000	0–10000	10000	0–10000	7000	0–7000

Table 1. Optimum conditions for flare illumination (direct).

Cosine Law Applied $E^2 = \frac{I^2 h^2}{(r^2 + h^2)^3}$

Average CP 10^6 candles	*0.025 foot-candles*		*0.05 foot-candles*		*0.1 foot-candles*	
	Optimum radius (feet)	*Optimum height range (feet)*	*Optimum radius (feet)*	*Optimum height range (feet)*	*Optimum radius (feet)*	*Optimum height range (feet)*
0.1	1000	350– 1500	800	350– 1000	550	250– 600
0.2	1500	500– 2300	1000	350– 1500	800	400– 900
0.3	2000	800– 2500	1300	400– 1900	1000	450–1100
0.5	2500	900– 3500	1700	600– 2200	1200	400–1500
1.0	3500	1000– 5000	2500	850– 3500	1500	400–2500
2.0	4500	1000– 7000	3500	1100– 5000	2500	700–3100
3.0	5500	1400–10000	4500	1500– 5500	3000	1000–4100
5.0	7000	2000–10000	5500	1700– 8000	4000	1400–5100
10.0	10000	2400–10000	8000	2700–10000	5000	1300–8200

Table 2. Optimum conditions for flare illumination (cosine law).

From Table 1			
Required illumination, foot-candles	0.025	0.05	0.1
Radius of illumination, feet	5000	4000	2500
Opt. height range, feet	0–4000	0–2000	0–2000
From Table 2			
Radius of illumination, feet	3500	2500	1500
Opt. height range, feet	1000–5000	850–3500	400–2500

Table 3. Comparison of illumination values for vertical and horizontal objects.

more realistic for ground observation of both vertical and horizontal objects.

A study was made by the Army Field Forces in 1951 which included an evaluation of existing battlefield illumination devices such as ground signals, grenades, artillery and mortar shell, searchlights, aircraft flares, and other miscellaneous devices. However, an evaluation under actual field conditions, using light measurements, of the present standard illuminating flares and shell was not conducted. This may be attributed, perhaps, to the shift in emphasis in the type of warfare likely to be conducted in the future; namely, the extensive use of missiles and rockets.

However, smaller actions, of the Korean type, as long as they are possible and occur, will require battlefield lighting, including pyrotechnic illumination of bombing targets.

Since World War II the light output of flares and illuminating shell has been increased from 100 to 500 per cent as a result of the intensive research and development in military pyrotechnics conducted at Picatinny Arsenal. Not all these advancements have as yet been incorporated into the present stock. Similar increases of 75 to 300 per cent in light output has been achieved for photoflash bombs and cartridges used in night aërial reconnaissance of bombing targets.

However, recently a new breakthrough in pyrotechnic composition research has been achieved at Picatinny Arsenal which will increase the efficiencies of flashes and flares to a much greater extent, particularly at high altitudes. The M138 and M139 parachute illuminating flares, when tested for operational suitability, were found to be superior to all similar items in the current inventory.

FOR many years, probably since World War II, there has been a difference of opinion among experts as to whether a hooded or shaded flare was superior to an unhooded flare. Some insisted that hooded flares were better and eliminated pilot glare, but many pilots objected to the AN-M26A1 parachute flare which is hooded, because of the flickering light obtained due to parachute oscillation. Final evaluation of the M138 and M139 flares and their hooded counterparts was made by the Air Force in 1956 resulting in the standardization of the unhooded types. Hooded flares had to be larger and heavier and were more complex and costly than unhooded flares.

The importance of battlefield illumination for the most effective night warfare should not be underestimated because of the emphasis upon the more glamourous weapons systems of rockets and ballistic missiles or space technology. Traditionally, battlefield illumination items have had to compete with lethal items in existing weapon systems and be adapted to them rather than being considered and developed on the basis of the optimum and most effective illumination system. Therefore, if a choice had to be made in the logistics, it was invariably made at the expense of the pyrotechnic item.

The time is long overdue when a study should be made to determine the optimum weapon system for battlefield illumination instead of trying to fit the pyrotechnic capability into weapon systems designed to be employed for other important purposes.

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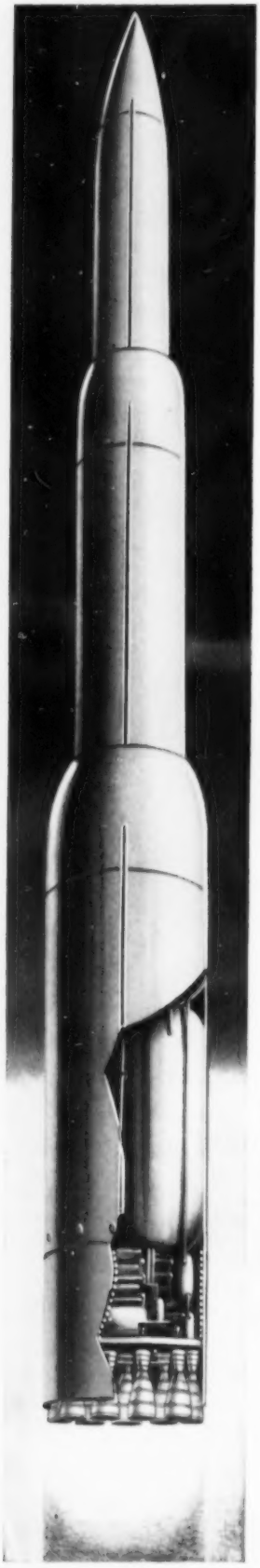

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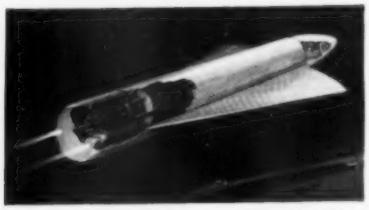
Once space is reached, a wealth of intriguing possibilities beckons. Entirely new aspects of propulsion are being developed to maneuver ships between the moving gravitational fields of Earth's neighbours in the solar system.

One advanced propulsion system that may be built soon is an ion rocket. This ultra-high-specific-impulse power plant provides low thrust for extended periods.



OUTWARD BOUND, *man's robot reporter heads off to a rendezvous with planet Mars.*

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NOVEMBER-DECEMBER 1958

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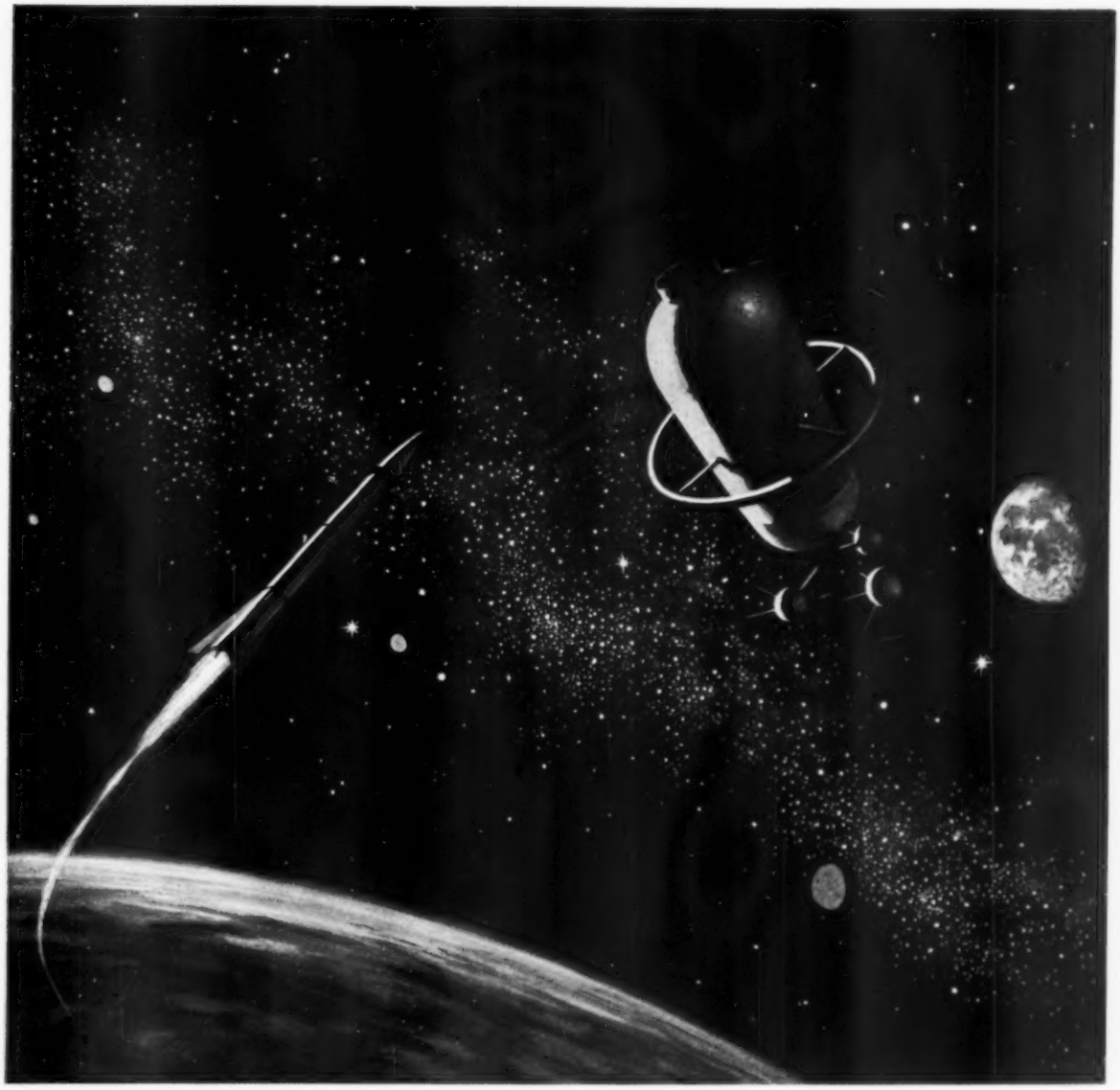

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